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Birmingham: F. E. Shearman, 63, Summerfield Crescent, Edgbaston, Birmingham.

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Newcastle-on-Tyne: H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne.

East Midlands: H. Bunting, 17, Marcus Street Derby.

Contents.

	PAGE
Notes and Comments	407
Position of the Iron and Steel Trades after the War	408
Deformation of Castings	409
Cupola Blowing and Efficient Combustion	417
Stobie 15-Ton Electric Furnace	423
Foundry Problems	427
Electric-Furnace Castings on the Witwatersrand	428
An American Foundry	429
Metal Substitutes in Germany	430
New Gas and Air Blast Crucible Furnace	431
Society of Chemical Industry	432
Salts for Heating, Quenching, and Tempering Steel	432
British Foundrymen's Association:—	
Annual Conference Discussions	433
London Branch	434
Queries	435
Deaths	436
Personal	436
Trade Talk	438
Legal	442
The Stanton-Holwell Amalgamation	442
Hardware Ration Scheme	442
Applications for Patents	442
New Companies	444
Monthly Price List	446
Small Advertisements	447

NOTES AND COMMENTS.

The Non-Ferrous Metals Act.

The Non-Ferrous Metals Act came into operation on August 6, and, as from that date, any firm dealing in these metals without a licence will be liable to severe penalties. It would appear that many manufacturing and merchant firms have not yet realised the important and far-reaching effect of this Act, under which no firm will in future be allowed to trade in non-ferrous metals, either as manufacturers or merchants, without a licence.

There exists some doubt as to the exact scope of the Act. It is, in fact, a matter for each individual firm to determine, with the aid of its legal advisers, how far its business comes within the scope. It is probable that in the case of, say, an engineering firm who buys brass ingots to manufacture, say, into valves, or other engineering products, the finished value of which is greatly in excess of the scrap value, the Act would be held not to apply, but it certainly would apply probably in most other cases and in the case of firms who purchase metal for manufacture and afterwards re-sell it before use.

Firms who use non-ferrous metals should ascertain as soon as possible their position. It would appear that many firms have sent no application in at all, whilst others have delayed sending one in until the last minute. Investigation is required into the *bona fides* of each firm to whom a licence is granted, and no doubt only a small proportion of the firms who will eventually be granted licences have as yet received official endorsement, and it would appear that this is owing to their delay in sending in their applications. Although an extension of time was allowed to firms whose applications had been received but not granted before August 6, so they might trade until their application received consideration, it may be assumed from the statements made in Parliament at the time the measure was passing through, that the Government do not intend this Act to be treated as a dead letter, and we should not be surprised to see prosecutions result in the case of firms who deliberately evade its provisions.

The Act has good points, and many are in favour of applying its provisions throughout the Empire. This, we believe, would be an important extension of the principle, and would be of the greatest service in reserving the metal trade of the British Empire for Britons. It was originally passed in order to eliminate enemy influences from the non-ferrous metal trade, in which enemy firms had acquired a preponderating voice, but it also may be used, and would advisably be so used, to prevent the illicit dealing in stolen copper and brass scrap, etc., which at present exists.

Degrees of Commerce.

That the Universities will have an appropriate part to play in Reconstruction after the war goes

without saying, and the University of London is to be congratulated upon being the first of the great British foundations of learning to realise that they may help the process effectively. During the progress of the war it has plainly indicated its opinion that as London may be rightly regarded as the financial capital of not merely the Empire but the world, the duty of London's University was to extend academic recognition to those forms of activity and business enterprise which centre here. During the last two or three years the Senate has acordingly founded Degrees in Engineering, Agriculture, Mining, and the Management of Real Estate. The departure has been viewed with something approaching dismay in quarters in which the belief still curiously lingers that the proper study of mankind is Greek or Sanskrit; but, nevertheless, these degrees have been established, and now the further step has been taken of adding Degrees in Commerce. It is all very revolutionary, we are well aware, but these are revolutionary times, in which business insists upon the fullest admission of its importance to and in the well-being of the national organism. Germany, in peace times, was not slow to advance her place in the commerce of the world by making her educational institutions and processes completely contributory. The scientists, merchants, engineers and financiers of Germany were not one whit more able or intelligent than our own, but along broad lines of technical and commercial education they were brought into intimate touch with each other and their intellectual gifts co-ordinated. We all know with what results—how in every branch of art and industry the country flourished and attained an amazing development, the fruitful end of which could with confidence have been predicted had not militarism intervened. Even if it should be alleged that the University of London has, in the new policy it has adopted, drawn inspiration from the Hun, the jibe will pass and the excellent ultimate effects of the policy remain.

ANALYSING FERRO-SILICON WITHOUT A PLATINUM CRUCIBLE.—Dr. Herwig, in a recent issue of "Stahl and Eisen," points out that it is possible to dispense with expensive platinum crucibles in analysing ferro-silicon and to use iron crucibles, if instead of the usual carbonate of soda and potash method sodium dioxide is used in the ignition mixture. Great care must be taken to reduce the ferro-silicon to as fine a powder as possible, to remove all coarse particles, and to mix the powdered silicon thoroughly and very uniformly with the dioxide, as otherwise dangerous ebullition might take place, which would nearly empty the crucible and the spattering endanger the analyst's eyes. The author gives a comparative list of 22 analyses made, one-half of these by the sulphate, the other half by the dioxide method, of ferro-silicons, ranging in silicon-content between 10.75 and 90.78 per cent. The differences in the results obtained by the two methods range only between say + 0.05 and − 0.13 per cent.

ELECTRIC STEEL CASTINGS.—In the discussion of a Paper on "Reversed Duplexing," before the American Electrochemical Society, Professor J. W. Richards stated that as regards the general question of the fitness of electric furnace steel for steel castings, for the information of the U.S. Naval Consulting Board, he sent a questionnaire to about forty or fifty of his friends in the steel business, asking how a better class of steel castings could be obtained. About nineteen out of twenty of these answers were that, other things being equal, there was a far better chance of getting a fine casting from electric furnace steel than from any other class of steel.

Position of the Iron and Steel Trades after the War.

A correspondent writes:—

The Report of the Committee to consider the Position of the Iron and Steel Trades After the War plainly shows:—(1) That the loss of Britain's position in the iron and steel trade was due to want of foresight on the part of the iron and steel makers in this country in continuing obsolete and costly plants and processes which America and Germany were changing.

(2) That this want of foresight was in a large measure due to the conservative policy of the various Government Departments ordering steel, and their refusal to accept anything but what their ancestors used. This policy was pursued even after the war had caused the shortage of steel to be a menace to our country and our Allies.

(3) That although our high costs of production, as compared with America and Germany, are partly due to the reasons stated in No. 1, they are largely due to the restricted output policy of the Trade Unions, which has caused one after the other important industries in the iron and steel trades in this country to languish and die. Whether this was due to unwillingness on the part of works to fix fair piece-work rates is not for merchants to say, but this is a matter which might have been gone into fully between the manufacturer and Labour representatives on the Committee, as it is the most important factor of all in deciding the position of the iron and steel trades after the war.

(4) That practically all the manufacturers' Associations whose reports are given, including manufacturers on the Committee, bought sheet bars, tinplate bars, billets, wire rods, and tube strip, etc., from America or Germany whenever the price showed the smallest inducement to them to do so.

(5) That the British export merchants have always done their utmost in every possible way to sell British iron and steel, habitually paying a premium for same when they felt they had discretion to do so. That their organisation has, unlike that of the manufacturers, been kept on modern lines and thoroughly up to date—equal in every respect to that of their competitors.

(6) That in pre-War years the British Manufacturer of iron and steel had found it impossible to finance his works and his wages bill, and at the same time have the necessary capital free to give the credit terms required in both the home and export trade. The merchant has paid cash before delivery or at latest cash on delivery—has repeatedly lent to manufacturers, including members of the Committee, against script, to help them through a difficult period—has given manufacturers raw material on long bill terms, relying on old friendship at times when their credit in the trade was looked upon as doubtful.

All this is now forgotten, at a time when the merchant is paying the full taxation he is due, and the manufacturers are getting back more or less of their taxation in the form of new works, etc. But money will not be plentiful after the war—the supply will again fall short of the demand—the merchant will again be called upon to finance the manufacturer, and after the war public money will not be available as it is at present, for any one privileged class.

The capital of the iron and steel merchants engaged in the home and export trades is probably equal to, if not more than, the capital of the iron and steel works of this country. If their business is to be stolen from them by the organisations suggested in the Committee's Report, it will be necessary for them in self-defence to start works of their own. It is, therefore, to be hoped that the small syndicate of iron and steel manufacturers formed with a nominal capital of a few pounds to invest in iron ore properties have not been given any monopoly by the President of the Board of Trade as was done in the case of the British Trades Corporation, and which monopoly had later on to be withdrawn.

Deformation of Castings.*

By T. Brown, Sheffield.

The present Paper is based on experiences derived from actual practice in the steel foundry.

Now deformation due to contraction and expansion is a subject that I am afraid is not seriously considered by the majority of officials and workmen who are in daily contact with it, and for want of that consideration a lot of unnecessary deformations occur, not only in steel castings, but in almost every other thing affected by heat.

My Paper to-day deals chiefly with steel castings. I am fully aware that contraction plays its part in cast iron, but not to the same extent as in steel, owing to the high temperature of the latter.

The contraction on cast steel is considered to be equal to about 1 in 60, but on cast iron a good deal less is allowed.

Now in some shops I know men are kept for the sole purpose of putting deformed castings into their proper shape as required for delivery. These men are considered very clever at this particular work, and I, without hesitation, say they are. Should a casting be badly out of shape, they, before it is put into the annealing furnace, make a careful study of how it should be packed, so that when hot enough it will bend by its own weight,

FIG. 1.

FIG. 2.

or, if the section is too strong, they will apply extra weight to bring it back to shape required when cooled down.

I have seen mistakes made with regard to packing in the furnace. I have seen every allowance being made for the particular casting to return to its shape, or it may have been right before putting it in the furnace, but no thought has been given to the casting expanding lengthwise whilst getting hot, with the consequence that it has been more out of shape than previously. Now this is a matter that needs careful consideration before the furnace is heated up.

The object of my Paper to-day is to try and show what I think would not only save a lot of anxiety to the foreman-in-charge, but would also save a great deal of the work done by the men referred to in putting these castings right, or the deformities which I think in many cases should not be there; and in endeavouring to do this I shall have to look to my friend, the pattern-maker, without whose help it is impossible for a moulder to be successful.

I will divide the deformation that takes place into two stages:—

First.—By contraction from the solidification of fluid steel down to complete cooling.

Second.—By expansion from the cold stage to the higher temperatures of annealing.

Take stage one. I shall endeavour to show by sketches on the screen how I think the pattern shop can help, and a lot of castings that are out of shape when cast, may be avoided.

Take Fig. 1, just a plain straight bar, its sections equal. There can be no resistance to contraction, and if allowed to cool in the sand one may expect to get a straight casting.

Take Fig. 2. In this case are also two straight bars, tied together at one end of each only. What do we get here? Contraction takes place along both bars to the point "A" which are tied together, and you may reasonably expect to get a casting again without being out of shape.

But take Fig. 3, and you have a different problem; there is resistance between the points A and B, and when the casting comes out you may get a shape taking the form of the dotted lines on the same sketch. These lines may be somewhat exaggerated, and on all my sketches they may be the same, but it will go to show that it is impossible for the casting to be correct to shape unless you have some help from the pattern shop, and the help required in this case is that the pattern shall be

FIG. 3.

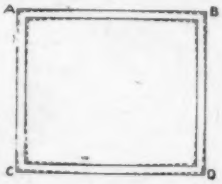


FIG. 4.

made with the ends A and B somewhat closer together than the corners C and D, so that when the casting comes out it shall be the shape required and not want any setting at the points A and B.

Now we will go on to Fig. 4, and see what takes place on a casting like this. The whole thing will contract on the lines A, B, C, D, all pulling towards each other, and the result, when carefully examined, will be as shown on dotted lines, again exaggerated, another lesson for the pattern shop, to save the labour of a man in setting to shape by other means after being cast.

I have purposely refrained from giving any dimensions on the sketches shown; I wish to leave it to your imagination what will take place if the castings are of large dimensions.

Now we will go from a square to a radial and see what occurs.

The resistance to contraction in a casting like Fig. 5 is equally distributed on its inside, and you may with some confidence expect a true casting; but I have seen castings of this description badly deformed, owing entirely, in my opinion, to want of thought. I will explain what I mean by want of thought. In some steel foundries if they had a ring to make of this description, say, 10 ft. diam., 2 ft. deep, and 2 or 3 in. thick, they would, after the mould is full and allowing time for the casting to set, start and get the inside out to relieve the cores, which is generally termed "liberating," to prevent it from "pulling." The consequence would be that only the top portion

B

*Read before the British Foundrymen's Association Annual Conference in Sheffield, June, 1918.

of the cores would at first be removed, and some time would elapse before the bottom was reached; this would allow the atmosphere to get at the top, and cool it first; it would then start to contract before the bottom, and consequently you would get a section as shown on dotted lines, Fig. 5, when it really ought to be square from the centre line.

Now, personally, on such a casting as this, I would never allow it to be liberated for contraction, but would prepare the mould so that it would be free for equal contraction from top to bottom, and avoid any contact with the atmosphere until nearly cold.

Now take this ring again, and make it into the shape as shown in Fig. 6, and see what the results of contraction are. Owing to the internal flange at point "A" not being very thick, the resistance from the core at that point cannot be very great, as it will cut its way to some extent; but not so with the flat surfaces B and C above and below the flange, which will have a great resistance, if of any depth above and below the centre. Therefore I would look for this casting when taken out of the sand to follow somewhat on the dotted lines in Fig. 6—another case for the deformation to be put on the striking boards or pattern before moulding.

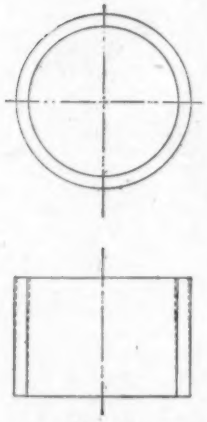


Fig. 5.

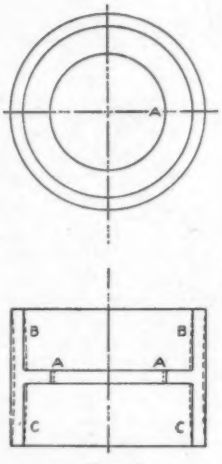


Fig. 6.

Another casting in the shape of a ring that steel founders are often called upon to make is Fig. 7. They may be 5, 6 or 7 ft. diam., or more, and perhaps only about 6 in. between the flanges; therefore it is only reasonable to think in this case that, the distance between the flanges being so small, you would not have very much trouble with deformities. Let us, however, take the same ring and make the distance between the flanges, say, 5 ft. or 60 in. (Fig. 8); then you will have to look upon the design somewhat differently.

I mentioned previously in this Paper that steel contraction is about 1 in 60, and as the distance between the flanges is 60 in., therefore it means when the casting is cooled down it will only be 59 in., with consequently the resistance taking place between the flanges, and I don't quite see how you can release it without allowing the atmosphere to play a part upon it, which will put it out of shape—as previously illustrated in Fig. 5. The consequences are that you have a badly deformed casting, taking somewhat the shape of dotted line on Fig. 8. In this case to avoid deformation it will be necessary to have the flanges somewhat closer together at the outer edge when making the mould.

Let us again take a similar casting of the same dimensions, but put the flanges inside (see Fig. 9), and you get the same result with regard to flanges being out of shape; but I contend that you will also have the body deformed. As the narrow edges of the flanges form somewhat of a cutting edge inwards against the core, it will almost allow the flanges to take their full contraction towards the centre, but not so with the body marked "A," as there is a great resistance of core, and the consequence is that you get a casting as shown on dotted lines (Fig. 9). I again must appeal to the pattern shop for help.

We will now go into the question of shape of gear wheels, or similar castings that are tied together at the rim. There are makers of gear-wheel moulding machines who guarantee them to be perfectly accurate in the moulding of a wheel,

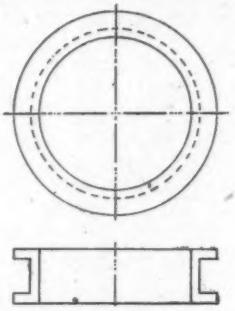


Fig. 7.

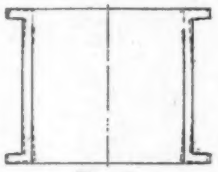


Fig. 8.

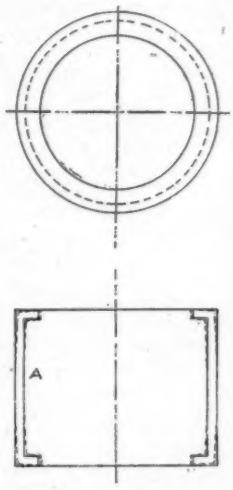


Fig. 9.

and I don't hesitate to say they are exactly just what is claimed for them; but there is such a lot of difference between the casting when it is stripped and the mould in which the molten steel was placed. Personally, I cannot believe that a steel spur wheel with arms cast in, and as a casting only without machining, was ever turned out perfest unless something was pre-arranged to allow for contraction. Now let us take a sketch of one and examine it. (See Fig. 10.) In the case of a spur wheel the process of contraction can only take place along the line of arms from A to B towards the boss or centre as well as contraction on its rim, as there is nothing to pull in the radial part at the centre C between the arms. I contend that you get a casting following somewhat as shown by dotted lines in Fig. 10, and therefore the pitch diameter cannot be true, and the same thing applies to blank wheels made of steel, and unless the pattern maker takes the precaution to thicken the inside of the radial part between the arms, he will find when it is machined on its outside, it will be thin at

the centre distance between the arm ends, and will be deformed, as shown by gear wheel, Fig. 10.

Now as regards gear or other wheels that are split at the boss, you have a better chance to get something more like the shape required outside, but in this case the deformation will take place at the boss, the contraction again occurring along the arms, and the tendency is to pull away from the boss owing to it being split, and the least resistance at the narrow point between the arms at boss. The consequence is that the splits open and come towards the rim, and, if care is not taken, the diameter of the hole at the centre will be much larger than it ought to be.

Take another wheel whose boss remains in one piece, but is split at the rim. (See Fig. 11.) Now what takes place on such a wheel? It contracts along lines A B of arms, rim to boss, and pulls inwards and between the arms that are tied together at the rim. It will take approximately the same shape as the gear wheel already illustrated, but, in that part of the rim which is split between the arms, a different contraction takes place. When the casting comes out of the mould you find that not only have the splits opened, but the part

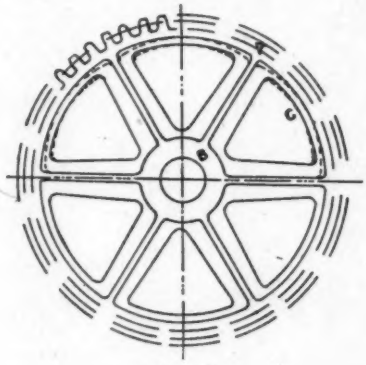


FIG. 10.

of the rim at each side of the split seems to be bent back out of shape, and something occurs as shown dotted in Fig. 11. It is only reasonable to think that the rim being split, contraction will take place around the periphery, and only from the points C D towards the centre E between each split, and the short part of the rim between each split is unable to pull in towards the centre owing to resistance of cores. Now this is a casting that needs a lot of study, both by the moulder and pattern-maker, to know where to thicken the pattern before it is put in hand, and to make sure of getting a casting, when machining is finished, of equal thickness and of perfect balance.

We will now proceed to another casting that sometimes has given trouble to the steel founder, and when it arrives at the machine shop it is out of shape and will not machine to dimensions. I refer to a piston. (See Fig. 12.) There is much difference of opinion as to the cause. It is sometimes said that the boss lifts in cooling, but my contention is that it does not lift nor yet does it fall. Now let us take some dimensions on sketch and study them; say, from A to B is 5 ft. or 60 in., which for simplicity equals 1 in. contraction; C to D, 15 in., equals $\frac{1}{4}$ in. contraction; and from E to F, 30 in., equals $\frac{1}{2}$ in. contraction. Now, my argument is that the bottom having to go 1 in. and the top only $\frac{1}{4}$ in. in contracting inwards, at the bottom it does not allow the top to fall, but instead pushes the cone inwards and upwards, so that no contraction takes place between points E and F, and therefore no allowance should be made in this direction. The same thing will apply to almost any casting that is coned, and if the drawing should give the degrees of angle of cone, great judgment will have to be used, or it will not be the correct angle when contraction is completed.

Some years ago I worked in a shop where many stern frames for merchant boats were made; they were of various designs, but the only one I want to refer to to-day is what is known as a plain frame. (See Fig. 13.) We never made one at that time which was not out of shape. I remember the pattern makers coming into the foundry to set the pattern after the moulders had prepared the bed for it; lines of string were used as well as straight edges and parallel blocks, and the pattern was set to what was considered to be perfect, yet when the castings came out and got to the machine shop they were not lineable as the pattern was

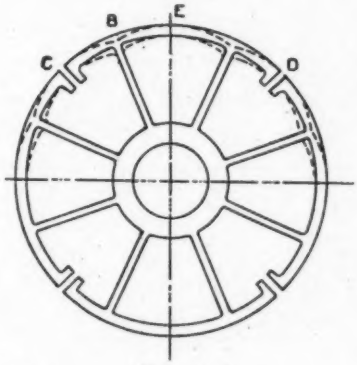


FIG. 11.

when set in the floor. Many things were considered as the probable cause, but the same thing constantly occurred. Eventually a man was appointed to make a study of setting the castings in the annealing furnace, with a view to bringing them back to shape whilst getting hot. I may here say that at that time I was equally at a loss as to the cause, but it only requires a little study to discover the real cause. The worst trouble was the lugs or gudgeons for carrying the rudder were never in line, although they were correctly set when putting the pattern in the floor.

Let us examine the sketch and see in what way contraction would affect it. Between A and B (these being almost two parallel sides and not far apart) it is only reasonable to admit there would not be much deformity in that direction, but across from C to D it is different, the distance between the points A and B being so far away from each other they could only pull or contract along the lines at points C and D, but it was impossible for it to pull together at the points D and E, with the result that one obtained a casting following the dotted lines, and when the centres of lugs were set to a line on the pattern, it was impossible for them to be in line when contraction had taken place; also the lugs or extensions G and H

were often out of line, and followed somewhat the shape as dotted.

This, in my opinion, is a clear case for the pattern-maker to set the pattern to the expected deformities when moulding, so that when the casting is knocked out it will not require the labour of a man to set it to shape. I have no doubt the shop referred to will by this time have solved the problem and taken steps to avoid such trouble, but I have only mentioned this as an illustration of what does take place if precautions are not taken.

Having shown by plan or section on most of my sketches what occurs by contraction in one direction, I will try and show that there are other directions in which contraction is taking place at one and the same time on the same casting. I want you to imagine a casting that combines most of the illustrations. (See Fig. 14.) On this sketch you have Fig. 6, shown in section on outside of rim. In Fig. 10 you have what takes place on a gear wheel along line of arms; you have at section of arms what happens between two flanges, or equivalent to Fig. 8 and 9, and again you have, as shown on Fig. 11, the result of it being split on the outside and contraction taking place to point A.

I have not dotted this sketch to show what really I think would occur if precautions were not taken, but will leave it to your imagination, after having seen previous sketches; also you must realise that a great amount of study is necessary between the pattern-maker and moulder before such a job is put

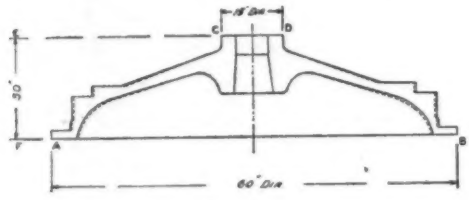


FIG. 12.

in hand to be sure of a casting that is reasonably to shape when cooled down.

Before proceeding to a further stage of this Paper, I wish it to be presumed that the interior or parts of moulds or cores where resistance is shown on my sketches, are made or arranged to offer the least possible resistance to contraction, but also strong enough to combat the strain caused by the pressure of the liquid steel and the feeding heads above the top, which are necessary to ensure soundness of the casting.

Another kind of deformity—if I may use the term—which sometimes occurs in steel castings, and in what I consider the worst form, is breaking due to contraction, and in these instances I must exonerate the pattern-maker. I will here verbally illustrate an instance that I personally witnessed. A base for an anvil block was cast; its dimensions from memory would be approximately 10 ft. sq. and 16 in. thick, with a dovetail piece running all round its top side for packing the anvil block. (See Fig. 15.) Now this was a breakdown job, and was most urgently required to replace a cast-iron one. I well remember it being cast, and to help it to cool quickly the boxes were removed from the sides to allow the atmosphere to reach it, and, as soon as it was thought safe to lift, it was sent to the fettling shop, and, as soon as considered cool enough to commence work, it was stripped on the top and the sides, the sand remaining on the bottom owing to the dovetail piece running all round it. In the course of a day or two it was turned over, and the sand taken from the bottom as cast. It was now cool enough (though warm) for some fettlers to sit on the top with hand hammers and chisels to level the surface where the anvil would rest, and whilst these men were so engaged it broke, and with a report equal to a heavy gun; it also brought down clouds of dust from the roof, which made it impossible to see either casting or men for some few minutes, but when all was again clear it was found that no one was hurt, a lot badly frightened, and the casting itself in two pieces almost straight across and 15 in. apart.

Now at that time I had no idea of what could have been the cause, but after having castings break under my own supervision, I thought it was time to look for the cause and the remedy, and the only conclusion I reached was that the castings were exposed to the atmosphere too soon.

Therefore, let us consider what happened in the case of the anvil base referred to. The outside of this casting being stripped, it was at once attacked

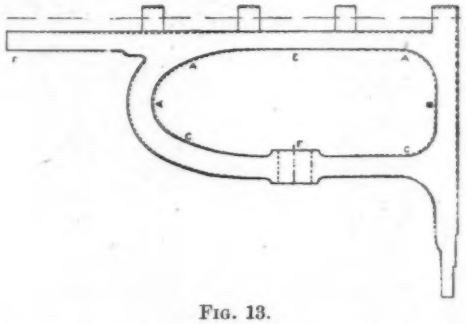


FIG. 13.

by the cold air, and in consequence would contract; its outside would be in compression towards the centre; this would continue until the outside was perfectly cold and compression had ceased; the centre being covered with sand was causing the heat to be retained at this part, and consequently as it cooled it would have to contract, which would now bring the outside into tension, such a strain being imposed between the two that one must give way; the result was that the outside or cooled part being the largest in area, the centre had to give with the result as stated, and the strain was so great that when it did break it caused the report referred to, and the sudden displacement of air brought all the dust down from the roof.

In my opinion the best way to prevent breakage of this description is to leave them in the floor or boxes, as the case may be, until quite cold, and prevent the atmosphere reaching any part of them. I know in some cases castings are removed whilst hot and put into furnaces to cool down, Even in these cases great risks are taken owing to the casting being attacked by air in the process of removal. I am convinced that the safest way is to leave them in the sand, which will retain the heat all over and allow all parts to cool simultaneously. I do not remember one case of a casting being broken before removal from the sand. I am fully aware that, to do as I suggest, a lot of

floor space, or a lot of boxes, will be required, but it is most advisable rather than take the risk of losing valuable castings. One of the most valuable assets a steel founder can have is plenty of spare room or boxes for any eventuality. This will always allow him to proceed with a new job whilst another is cooling in the floor or boxes.

Now I come to the second stage of my Paper, namely, castings deformed in passing from the cold state to the higher temperatures.

It is always essential that steel castings should be annealed or otherwise heat treated. It is in this process we get the deformities I wish to refer to. I have seen castings considered perfect to shape before being put in the annealing furnace, but, after being allowed to cool and removed therefrom, they have been various shapes. There are several reasons for this, but I will refer only to one or two causes. First let us look at a furnace where you have the heat coming in on one side or end only. The consequence is that the part of the casting nearest to the fire or gas is the part to become hot first, and will expand before the other parts reach the same temperature, and this is when it

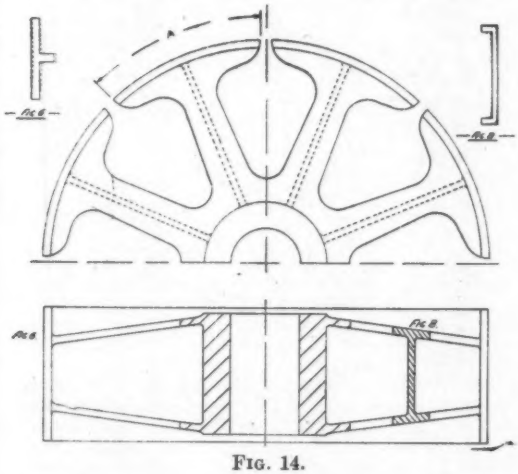


FIG. 14.

loses its shape. In some castings it may not matter much, but in others it becomes serious. Take for instance a large spur wheel with only a part of its rim exposed to the flame, and you can imagine that that part of the rim will expand and be out of shape, and will keep out of shape till the whole thing is heated to one temperature, if such a thing is possible in the furnace referred to. When this state is reached the part that first commenced to expand is still out of shape, and as it cools down gradually and equally it is impossible for that part now out of shape to return to its original form, and the consequence is a deformed casting.

Another cause; perhaps entirely owing to the the manner in which they are packed in the furnace. I have seen castings that have fallen over in the furnace when expansion has taken place, entirely owing to packing not being of sufficient size, and also due to no allowance being made for the expansion. When this does take place, the packings are pushed away and fall; then you can imagine what happens to cause them to be out of shape when taken from the furnace.

Another cause; perhaps entirely owing to the small number of furnaces at your disposal you are compelled to put in more castings than really ought to be, with the result they are touching each other and probably one wedged within the other. It is easy to imagine what might be expected when heated to the required temperature. During the state of expansion one is pushing against the other, and, of course, the weakest has to give way, and, owing to this fact, you have several castings out of shape.

Now referring to annealing furnaces: I have not yet seen, in my opinion, the ideal furnace. All the furnaces in my experience have been, as I mentioned, constructed so that the heat came in at the side or end only; but my idea of a furnace is one wherein the heat is distributed on all parts inside the furnace at one temperature, thereby preventing one part of any casting getting hotter than the other. Then expansion would take place equally, and with care you ought to have castings undeformed when taken from the furnace. Now I

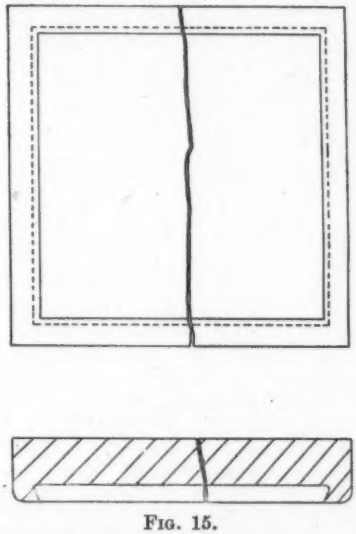


FIG. 15.

would suggest this matter as a basis of careful thought on the part of the furnace builder or designer.

I will now proceed to what I termed in another part of my Paper the worst kind of deformities, that is the breakage of castings. I refer to breaking after removal from the annealing furnace, which I do believe with proper care and less speed could be avoided. It is only another case of allowing the atmosphere to attack it before being properly cooled in the furnace.

I will give one or two cases of which I have personal knowledge. The first I refer to was a large fly-wheel about 13 ft. diameter, with a light boss and six light arms, as compared with a very heavy rim. (Fig. 16). Great care was taken with these wheels after being cast, and owing to shortage of floor space for moulding it was necessary to put them into a furnace whilst hot, to cool. When one was considered sufficiently cool, it was taken out, but next morning it was found to have broken through the rim, also through three arms. Now let us look for the cause. I may say at first when it was taken out it was not quite cool, although

considered safe, but proved not to be. What took place was, the rim having very little sand attached, the fettlers started to knock it off the boss and the arms, thus allowing the air to attack them, and being of light section were first to cool by contracting towards the centre, thereby putting the arms in tension from the rim. The outside being warm yielded to that tension, and this continued until the boss and the arms were cool, and contraction completed; but with the rim such was not the case, and being of much heavier section did not cool so quickly, and consequently the contraction proceeded after the arms were finished. The arms having already contracted, would not yield, and the result was that the rim had to give way and break. An illustration showing the wheel and fracture will help to confirm my contention that had it cooled down simultaneously in all parts, the rim would have been slightly smaller in diameter, which would have filled up the fracture at A.

Now I will give another case of a fly-wheel

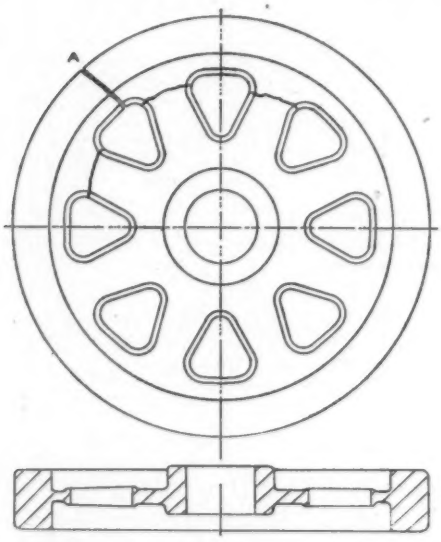


FIG. 16.

which occurred recently. This was a plate wheel about 12 ft. diameter and 8 in. thick plate, without a heavy rim, as the latter was cast separately. Everything went well with the wheel from the cast to being partly dressed, when it was put in the furnace for annealing, which so far was all right; but owing to the urgency of the job and the furnace being required for other urgent work it was regarded as safe to take out, but, unfortunately, the result was disastrous. What happened was that, owing to the plate being thin as compared with the boss and feeding head combined, the air attacked the plate and caused contraction and compression towards the centre till quite cool on its outer surface and contraction had ceased; but, owing to the centre being of much heavier dimensions, it did not cool as rapidly as the plate, which then caused the outside of the plate to be in tension, with the consequence that the strains then set up caused the wheel to crack right across; but it did not fly apart, and the only thing visible on the outside was a hair line, and the centre had opened $\frac{1}{8}$th of an inch, which proves that the outside had ceased contraction before the centre part had contracted to its minimum dimensions.

Now, having stated some of the troubles the foundryman has to face, I do hope if any engineer is present to-day, and who has not in the past given much thought to foundry work, it will at least convey to him that there is some scope for his energies in this direction.

I am afraid that the art of founding, or the foundry and its work, has not in the past had the attention given to which it is entitled from the engineer.

I am glad to see that other writers of Papers given before other branches of the B.F.A. have been drawing the attention of engineers to designs of castings with a view to helping us to overcome many troubles, and I will be amply repaid for my Paper to-day if, through the help of this Association, it will cause engineers to take up and seriously consider foundry work and its requirements,

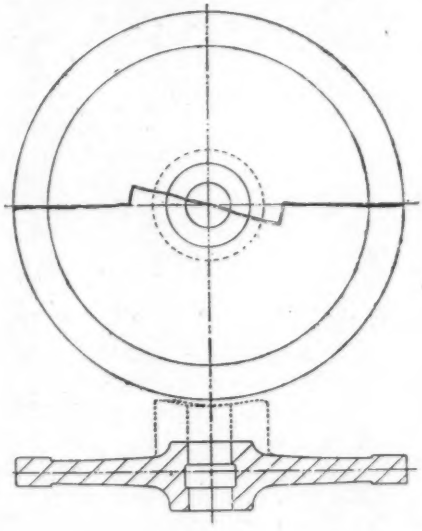


FIG. 17.

as I am confident there is ample room for a great deal of study.

Discussion.

MR. JOHN WATSON (Sheffield) was not entirely in agreement with Mr. Brown, and he thought the author might reconsider the length of the contraction on the wheels and also the length of the arms and of the rim between the two arms. It would have helped them if he had given them some idea of the medium between those contracting parts. Personally, he thought the condition of the moulding sand had a great deal to do with deformation. He found when they used ordinary "compo" in the casting of wheels there was always a hollow on the rim beside each arm. But several different kinds of core sands were now coming into use, though very slowly. He had found silica core sand bound with oil to be a decided improvement, and it enabled him to do away with irons altogether in certain cores. It was possible to make a triangular core with silica sand

and reduce the thickness of the corners to within half an inch of where the steel touched the core, so that when the contraction came on the core would crush and avoid any deformation of the casting. That class of core offered no resistance whatever to the contraction on the wheel. The hollowness he had referred to had disappeared, and they had secured perfectly round wheels. In manufacturing small links used in the "tanks," and weighing 14 lbs. each, they employed a special method, and when they used compo cores the flanges were always hollow by one-sixteenth of an inch. But when they used the silica sand bound with oils, both flanges were found to be perfectly shaped and a flat casting was got. Another point where the moulder sometimes went wrong arose from the difference of opinion on the question as to whether the mould should be cast hot or cold, and his own impression was that when they cast in very hot moulds they got the casting out of shape and out of size. Mr. Brown had related how breakages had happened through strains when cooling. He entirely disagreed with Mr. Brown. The author's idea was that the casting should be left in the sand until it was quite cool, yet he (Mr Watson) had found that a casting so treated was in such a condition that when the fettler hit it with a hammer it broke right away His own practice was to lift out the casting as hot as possible, and, having everything in readiness, to get it into the annealing furnace as quickly as possible But it was first necessary to rough out all the cores. They had to remember that generally when a casting was put into the furnace some parts were quite clean of sand, while others were not. The result of that was a most unequal heating causing a sort of patchiness on the casting. It was much the better plan, after the first annealing, to get the fettlers on it as quickly as possible, cleaning off the sand, and then anneal it again in a clean condition. That was the best remedy for casting stresses. He had known castings crack through being brought out of the foundry after remaining a long while in the sand, but he had never had a burst under the conditions he had described. When he introduced the new system the men at the annealing furnace during the second annealing rang him up and said there was something wrong because, as they said, the casting was not "talking" to them. They had invariably heard a kind of crackling when the casting was put into the furnace which they called "talking," and they were considerably astonished that the casting in question made no such noise. The patches of sand left on a casting did a great amount of mischief in the annealing furnace. He thought Mr. Brown was quite wrong in leaving a casting to become quite cold on the floor. It should be understood that he was discussing large castings.

Mr. F. J. Cook (Birmingham) remarked that with large fly-wheels of the disc type made in cast iron the strains were very much reduced if the plate was designed conical instead of flat. With many of these castings ranging in weight up to 25 tons this method had proved very satisfactory.

Mr. W. Mayer (Dumbarton) said he had seen all sorts of malformed castings, and there was something in Mr. Watson's argument. He had seen in his own experience, with good results, the odd arm system adopted in making wheels for rotor turbines and other wheels of all kinds in both steel and iron, when great strength was required, and with less risk of a breakdown. By that system the direct line of contraction was broken and reduced in length, and it likewise had a tendency to reduce the tension strain that was left in the casting, after it had contracted to the limit in cooling. With regard to the cooling of castings, his own practice was, whenever he could leave a casting to lie and cool, to do so, and he could always make provision for contracting by means of the cores.

For an example there was the soft loam-brick system that had been found very effective and largely used as an easy means of getting over contraction risks and troubles. Then, again, there was the wood contraction bar put into large cores of the box form, which was very good, because it burned away as the core got heated and the casting had started to contract to the final stage. Likewise there was the easing of contraction by a taper bar made of cast iron and rather more than the width of the main core walls (in large round and flat cores such as condenser cores with open ends) that could be knocked back with hammer and screw jacks. There was undoubtedly a great deal also in making them in sand. On the whole, he knew that the steelfounder had more difficulties to contend with than those dealing with other metals, and he spoke with a large experience of iron and brass castings. He had suffered most when using Middlesbrough iron, which was notoriously weak. They were obliged to do something to overcome it, in view of the amount of phosphorus and silicon in the iron. Eventually, they adopted the system of long taper bars, especially with the cores, and that enabled them to drive or screw them back. However, he thought it was better to let the castings lie, especially with steel, in which the trouble was more acute. There was great practical value and utility in Mr. Brown's Paper. (Applause.) It was a clear statement of how to avoid or get over some of the troubles that were with the steelfounders every day.

Mr. A. R. Bartlett (Belvedere, Kent) said it was interesting to note, from Mr. Brown's remarks, that the practice in the steel foundry as propounded by him was similar generally to that appertaining to the production of grey-iron castings, more particularly to those of a larger type, his statements as regards distortion and contraction showing that they were identical with the grey-iron casting of the same shapes and types. His co-operation with the pattern shop to meet and counteract the deformities mentioned, was undoubtedly the correct way to avoid this trouble, rather than the way some firms had of getting over it by packing in the annealing ovens. No doubt the ideal way was the adoption of the old adage, "Prevention is better than cure." He (Mr. Bartlett) did not believe it would be a sound proposition to make cores entirely of loam, because they would probably resist the pressure and cause a great deal of the deformations spoken of. His own practice was to build up a stick or sticks in the core, then to withdraw it and fill the space with silica sand. When the contraction began the silica sand would crush and fall away, thus giving the casting the opportunity of contracting freely and keeping its shape in the mould till thoroughly cold, thus not causing any undue strains to be set up by sudden exposure to the air while contraction had still to take place. The interior part of the drum of the flywheel was formed only of cores.

He believed it was quite ordinary practice to build up the interior cores in that way. With regard to the distortion of the boxes in the stoves, they had fairly got over that trouble. They found that the boxes expanded in the stove, and knowing that cast iron grew under heat treatment, and never came back to its original size, and that the sand contracted under the heat, it was obvious that the sand was smaller than the box, therefore the mould was smaller than was required, and cores would not fit the prints prepared for them. He had got over that difficulty by adopting a hot-air system which reduced the expansion of the box; the moulds were dried on the floor, the heat being directed to the mould and not allowed to affect the box. It had been suggested that steel castings should be taken out of the mould as quickly as possible and put into the annealing oven. But with cast iron that was not an easy matter, although it was true that they had to do this with chilled car-wheels and work of a similar type. He had a system of leaving the casting in the mould as long as possible. In fact, the men at his place had nicknamed him "The Normaliser," because he advocated leaving the castings in the mould until they were normal. They found that this reduced the strains likely to be set up.

Mention had been made of core irons growing in the stove. He had found that these sometimes caused trouble, and consideration should be given to this matter and irons made to offer as little opposition as possible to the tendency to grow and distort the core. Of course, the patternmaker worked to a drawing, and the relations between the foundryman and the patternmaker were not always ideal. In his own case he was very fortunate, and he invariably consulted with the patternmaker as soon as the drawing came in, and they got over the difficulty by having the core boxes slightly smaller than they were represented in the drawing, thus getting cores in the desired position, without undue cleaning. He had had his experiences of distortion, and for a time he invariably found that drums split in halves were more or less flat round the edge next to the splitting face, even though split through the centre. He thought, on the whole, it was more or less a question of design. People would not design the drum with the arms on the split line, with the result that the end of the rim was liable to drop outwards. To overcome that he got his patternmaker to line it up on the inside, so that after the casting was machined the thickness was even throughout. Like Mr. Brown, he had had large castings split, through being a little over-anxious to push a job forward. But he found it sufficient to leave the casting in the sand until it was quite cold, and thus remove this trouble. But he still believed that the commonest causes of the breaking of cast iron were connected with imperfect design. He believed that most of the troubles were directly due to inequality of thickness. Fortunately for himself, he was able to get a good deal of co-operation from the drawing office.

Mr. F. W. Finch (Gloucester) said he was very glad to have the recognition by the author, and especially by the last speaker, of the importance of the patternmaker. He wished that other firms would make the same recognition. Whenever an apprentice came down to the foundry to look around they should never interfere with him, especially if he was looking at a mould. A period of 12 months in the foundry would do a great deal of good to an apprentice, and he had adopted that plan with his own son by letting him start as a coremaker.

Mr. Brown, replying on the discussion, said he was glad the Paper had raised so much interest. He was unable to agree with Mr. Watson as to the important part played by the sand in resistance and deformation. If a wheel were laid on the floor in a hot state it would not contract equally, whether the casting were large or small. If they took a casting of 4 ft. square with a 2-in square section and got it up to a white heat and laid it on the floor it would not contract back perfectly. There would be no resistance except that of the atmosphere. Undoubtedly there was danger in connection with drying in the stoves, because the boxes naturally got hotter on one side than the other, and were very liable to deformations during the drying process. He entirely disagreed as to the safety of lifting castings out of the sand before they were cold, and undoubtedly there were other members in the meeting who agreed with him as to the dangers of lifting out a casting too soon. He thought it much safer to leave it in the sand, and he felt quite certain that Mr. Watson was wrong. With reference to Mr. Cook's remarks on dealing with large wheels, the meeting might remember that in his (Mr. Brown's) previous Paper he described similar troubles with smaller wheels. He fully recognised the special difficulties attaching to rotor wheels for turbines. As a matter of fact, he got over those troubles in exactly the way described by Mr. Cook. Fortunately those armed wheels were machined all over. They found that by thickening the arms and putting a lot of "machining" on the top at one end and a lot on the bottom at the other, causing it to be coned, it was possible to bring the arm back to shape. No doubt the difficulties in dealing with the flywheel could be got over in the same way. If the designers would invite from the foundrymen their ideas with regard to design, that would be one of the most effective ways of getting over difficulties. Really, the design ought to be submitted to the foundryman. He had claimed in his Paper that the moulds would be prepared from the practical foreman's point of view in such a way as to give the least possible resistance in every respect. But even then it was impossible to get proper results if the design was not perfect. The casting would go wrong during contraction. With regard to turbine wheels, he had had a great deal of difficulty, and he believed his firm was the first to get over one of the biggest difficulties, and that had to do with the split wheels on the outside. They solved another problem by putting an odd number of arms in the wheel.

The council of the Birmingham Metallurgical Society are launching a scheme to award scholarships at the University for Technical School students in metallurgy. It is proposed to raise a fund of £2,000, which will provide the necessary income.

The directors of the Vulcan Foundry, Limited, of Newton-le-Willows, have decided to capitalise £44,877 of the undivided profits and distribute in scrip among the holders of ordinary shares proportionately. This will work out at one share in ten, and will be the fifth such bonus since 1912-13 all of equal amount, namely, 10 per cent.

Cupola Blowing and Efficient Combustion.*

In all empirical works practice there is certain to be some conflict of ideas and lack of agreement in published data. Particularly so is this the case with the design and operation of the cupola furnace as employed in iron founding. While a large number of users may agree on the general lines of the cupola's construction, they will be found to hold very divergent views on the features of the blowing system—blast pressure, quantity, tuyere area, etc.—and also on what might be considered fair fuel consumption per unit of metal melted. Even amongst authors of text-books on foundry practice there is found a total lack of agreement on what one might expect to be standard matters.

In the event of a founder desiring to start a new ranked as matters to be determined by direct calculation from the factors first enumerated. But it is no uncom- cupola furnace, he should determine, among other things, the size or diameter required to give the necessary output of metal per hour, the quantity of air that such a furnace will require to receive per ton, and the velocity with which the quantity in question should preferably be delivered into the cupola. The style and capacity of blower, the size of blast main, and the number and size of the tuyeres, should be strictly mon thing for the founder to start by deciding on a size of furnace which someone has said ought to give approximately a certain output, then installing a blower and pipe system of an indefinite capacity, and finally increasing the output of the blower until a water-gauge somewhere on the blowing system records a figure which on some other system and cupola has been found to correspond with a fair output. There is little attempt to develop on the basis of known or ascertainable facts a system which will give the highest possible efficiency. Nor is this surprising when it is found how loosely most writers appear to regard the correlation of the various factors involved.

The writer has at various times examined published statements regarding the design and operation of foundry cupola furnaces with the object of ascertaining whether it were possible to establish some general rule co-relating the diameter or capacity of a cupola, the size of air conduits and tuyeres necessary to supply the requisite air, and the blast pressure. Published statements in regard to tuyere area, blast pressure, coke consumption and other details of cupola construction and operation, however, vary so much that it was found impossible to co-ordinate them.

Writers on cupolas and their operation commonly assert that one or another blast pressure is necessary for a certain size of cupola. Such a procedure is to start at the wrong end of the argument. In considering this subject we must first enumerate the facts in their order of relationship, as follows:—

(1) The sectional area of the melting zone of the cupola (not the stack area) determines the quantity of fuel and metal which can be subjected to combustion and melting respectively at any given moment on one plane; therefore, the size of the melting zone should be quoted as the size of the cupola.

(2) The quantity of metal to be melted determines the quantity of coke (or its carbon content), which, when combusted, will give the requisite heat, due allowance being made for heat losses.

(3) The quantity of coke to be combusted determines the quantity of air at a given density which must be introduced.

(4) The quantity of air to be introduced determines the tuyere area necessary to convey it at any given velocity of rate of travel, the tuyere area being corrected for capacity according to the number of openings employed, which greatly affects the friction and hence the velocity.

(5) The capacity of the tuyeres determines the size of air main required to supply the quantity of air, and hence, also, the blower output requisite.

Working back on this principle from cupola to blower it should not be difficult to establish with fair accuracy the data for constructing an efficient blowing and melting system, when the quantity of air required per period of time for the charge is ascertained.

Fuel Requisite for Melting.

It is first necessary to ascertain what quantity of fuel per unit of iron is required to be properly combusted to raise the metal to the desired heat, the presumption being that the blast will be arranged to perform this. Under ideal conditions a theoretical calculation based on the carbon content of the coke would be quite a simple matter; but working conditions are not ideal, and various disturbing factors must be allowed for, though they cannot be readily determined accurately. Taking first the coke and figuring it out on its carbon content, we may start with the fact that 1 lb. of carbon requires 1.33 lb. of oxygen (or about 5.76 lbs. of air) to burn to CO, and 2.66 lbs. oxygen (or about 11.52 lbs. of air) to burn to CO_2. Theoretically 1 lb. of carbon combusted to CO_2 should generate sufficient heat to melt 50 lbs. of iron, if all the heat were utilised to that end. But there are considerable losses of heat: (1) in melting the slag; (2) in heating the lining; (3) in heating the nitrogen of the air which passes away in the stack gases; and (4) by radiation from the cupola itself. Practice appears to indicate that less than 30 per cent. of the possible heating effect is actually applied to the iron, and a fuel ratio of 1 to 10 of iron is considered good by most foundrymen. It must, of course, be remembered that foundry metal requires to be more than just melted; for light work it needs to be raised well above melting-point. Hence the class of work affects the ratio of fuel consumption, and while the 1 : 10 might be obtained for heavy work, the same cupola might take 1 : 8.5 for light work if the same iron were used.

The bed coke, however, introduces a disturbing element in these calculations, for the amount varies very considerably with different furnaces. Some practice demands a deep bed charge, while in other cases the cupola construction necessitates only a light one. On this account the calculation of fuel ratio should be based on the charges after the bed charge, for only thus can the efficiency of the apparatus be checked.

Air for Combustion.

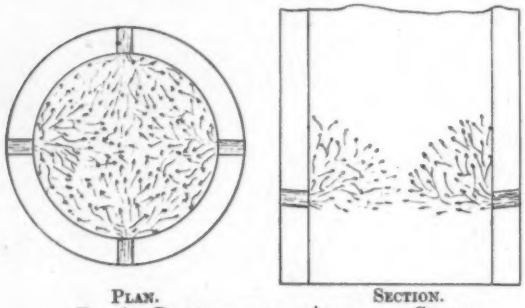
For the present purpose, however, we may assume that a fuel ratio of 1 : 10, excluding the bed coke, is necessary for a certain class of work. The fuel and metal are arranged in juxtaposition, and it only then remains to supply the correct quantity of air for combustion before the process may be started. It is obvious that though the actual quantity of air required by the fuel in any given depth of the cupola could be easily determined, that quantity may be supplied either at a very slow rate, just sufficient to support combustion, or at any greater rate up to the maximum rate at which the oxygen will combine with the carbon of the coke. The area of coke which can contact with the incoming air sets the limit to the rate of combination or combustion; therefore, since the actual surface area of coke (or carbon) in the given space in question which can be brought into contact with the air is limited by the area of the cupola and the surface area of the coke pieces, it is obvious that the air must be supplied at some particular rate in order to get the maximum rate of combustion.

If the coke were a solid mass presenting a plane surface it would be easy to calculate the area of contact with the oxygen or air; but a mass of coke pieces interspersed with irregular pieces of metal is very different, particularly since an increase of pressure not

* Read before the London Branch of the British Foundrymen's Association, by Capt. Alex. Hayee; Mr. T. W. Aitken in the chair.

only supplies more air to the surfaces of first contact but also causes penetration of the air to higher planes in the coke mass and hence increases the surface of contact. The size of the coke pieces and the physical structure of the coke are also variable factors, and it would, therefore, appear that the maximum efficient rate of supply for a given coke of a given size can best be determined by practical experience.

This involves not only determining the actual amount of air entering the cupola, but also how nearly its distribution is as efficient as possible through the plane of its introduction. When determining, first, the amount of air being supplied to a given plane of the furnace it should, of course, be clearly remembered that the actual recorded velocity or rate of travel of the air into the cupola does not of itself indicate anything. It is only one of the factors in determining the quantity of air introduced. When a given amount is passed through the tuyeres it encounters a mass of coke through which it can only penetrate by tortuous routes leading in all directions, and the distribution is approximately on the lines of diagram Fig. 1. There is, of course, a tendency to travel upwards more rapidly than inwards, owing to the resistance of the opposing tuyere's current and the lack of outlet other than at the top; but it has been fairly conclusively shown that the area of effective contact or the chief combustion zone takes the shape of an



PLAN. SECTION.

FIG. 1.—DISTRIBUTION OF AIR IN THE CUPOLA.

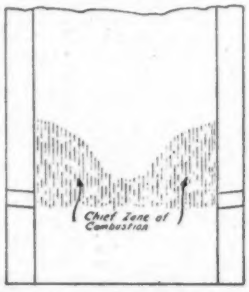


FIG. 2.—CHIEF COMBUSTION ZONE IN THE CUPOLA.

inverted cone, as in Fig 2. Although the centre of the cupola would appear to receive air at the least velocity, by reason of the fact that the currents from the different tuyeres all converge to the centre the quantity there may be as great as at the periphery on the same plane, though the supply would not extend so far upward in the centre as at the periphery. Taking a plane at any point a little above the tuyeres, melting probably takes place across the whole area. The zone of highest temperature, however, will tend to come nearer the lining continuously the higher the plane is carried; for as distance from the tuyeres is traversed the space for expansion becomes greater. Experiments have indicated that this theory is correct.

Increase of Quantity of Blast in a Given Zone.

Velocity or rate of entry, then, is by itself of no significance in determining the quantity of air supplied. It is, however, a factor in determining the distribution of the air in a lighted cupola. With a charge of coke unlighted the air would traverse approximately the same distance inwards for any combination of velocity × tuyere area which gave the same quantity of air per second; for the course of the current is broken up by the coke, and once it has entered the cupola the pressure as a factor becomes absorbed in the resultant or quantity and loses its identity. But after the coke has started to burn, the cutting action of a small current at a high velocity would be greater than that of a larger current at a lower velocity and would have also a greater chilling effect at the entrance by reason of impinging the same quantity of cold air on a smaller area. It is for this reason necessary to determine the rate of entry or velocity which is the minimum for pentrating to the centre of the cupola. For this reason there is obviously a minimum rate of entry, or velocity, at which it is desirable to introduce the correct quantity, though the writer contends that given proper tuyere distribution and area the velocity could often be well below that usually employed and more equable working thus obtained.

Taking any given diameter of cupola bosh, the rate of combustion of the coke therein is determined by the rate at which oxygen (air) is brought into contact with the carbon. If the lighted coke in a given plane zone through the bosh is supplied with an increasing quantity of air, there is reached a maximum quantity which can combine in a given time in that zone. Should the rate of supply be still further increased, the surplus must pass to a higher plane, or in other words increase the depth of the combustion zone. This, however, cannot be continued indefinitely if the air is still introduced entirely at the same point; for once the maximum rate of combination of oxygen and carbon is reached, any excess of air that has to pass through the zone in which that action is proceeding serves to dissipate or abstract the heat of combustion, transferring its effect from the metal in that zone to a higher plane, even though that higher plane may be one in which combustion is taking place. As the blast introduced at one plane increasingly exceeds the maximum rate of combustion possible, effective melting in that zone decreases and combustion serves to heat the air for a higher plane of combustion. Moreover, a chilling area is created through which all the melted metal has to fall before reaching the well or crucible of the cupola, while a still more dangerous feature is that such excess of air creates an oxidising zone through which the molten metal must pass, producing what is commonly known as "burnt" iron. This is a familiar occurrence when an excess of air is introduced at one plane or point in a cupola, though the remedy usually adopted is not to redistribute it properly but to decrease the supply—a policy which is good if the total supply is actually excessive, but wrong if the excess is merely local.

It may be deduced from the foregoing that the maximum quantity of air that may be introduced into the cupola at one level is that quantity which will support the maximum rate of combustion in that zone. If it is desired to increase the depth of the melting zone, the excess air should be introduced at a higher point, *above* the hottest portion of the original region of combustion, but not above the point when sufficient heat is already being generated to allow the new air supply to form the carbon-dioxide combination—if introduced too high it simply serves to convert further carbon to carbon-monoxide and wastes fuel to no purpose.

In the facts just mentioned would appear to be the explanation of the conflicting claims put forward by

various experimenters as to the value of second and third rows of tuyeres. When the quantity and distribution of air from one row of tuyeres is such as to give the maximum rate of combustion in that zone, the introduction of excess air at too high a point to extend that zone effectively would obviously be bad and wasteful. But if less than the maximum rate of combustion were resulting from the tuyeres in the first zone, the introduction of air under pressure at a higher point would tend to hinder the passage upward of the lower current and keep it longer to combine in its own area, while also creating a higher combustion zone which might merge into the lower one. With correctly proportioned air supplies at the different levels, even a third row might be effective, particularly with large coke, by reason of starting combustion on the exterior of the lumps which would progress inwards to finish combustion in the lower zones of the furnace. This, however, is in practice rarely effective, as the third row comes too near the outlet of the stack to do more than create carbon-monoxide.

In the opinion of the writer, the single row of tuyeres should give the best and most regular results, if the area and blast pressure are correctly proportioned; though it must be admitted that under some conditions more rapid melting might conceivably be got by increasing the depth of the zone of combustion by means of a suitably-placed second row. To determine this with any given cupola (and also class of coke) it would be necessary: (1) to determine by experiment the velocity and quantity of supply necessary to give the highest rate of combustion from one row, and then introduce a further air supply at the top and less active portion of that zone, so as to increase its depth. Moreover, the limit to the useful extension of the combustion zone is set by the quantity of products of combustion rising from the lower portion of the furnace. About 79 per cent. of the air blown in is nitrogen, an inert gas from the combustion standpoint, and this with the CO_2 resulting from combustion in the lower zone causes excessive dilution of the gases in the upper portions of the furnace, preventing useful combustion.

Calculations for a Given Output.

Having decided upon the required output per blowing which the cupola must give—merely a matter of the foundry's output—there are two courses for the founder to follow. The first is to instal a cupola of the lowest capacity which will give the amount and then operate it to its full extent; the second is to instal a larger furnace and either operate it at under its maximum rate or for a shorter period per blow. The second is the better policy, as it allows a certain flexibility of capacity to accommodate unusual demands. There is always a tendency, too, when forcing a cupola to wear the lining at an abnormal rate, necessitating excessive repairs at each blow.

In gauging the size of furnace necessary for a given output, however, there appears to be no reliable data at the disposal of the founder. The capacities of output per hour for a 48-in. cupola, for example, quoted by different writers, vary from 2.5 to 7.4 tons. These discrepancies obviously arise from difference in practice as regards quantity and distribution of blast, and to some smaller extent from difference in the physical nature of the coke. Still, if we are to take these figures as authentic the highest might be chosen as representing at least a possible output. In view, then, of a figure recorded by West for a 48-in. cupola of 7.4 tons per hour, we may assume that 7 tons at least is attainable. (It may be mentioned that the fuel/iron ratio in the example quoted was 1: 11.4.)

Next must be gauged the fuel ratio to be aimed at. While 1: 11.4 is stated for the case above, most founders can only attain about 1: 8, though some claim 1: 10. Accepting 1: 10 as possible, the fuel to be combusted per hour for the 7 tons of metal to be melted would amount to 0.7 ton or 1,568 lbs.—say, 1,600 lbs. This coke figured at 90 per cent. available carbon would represent 1,413 lbs. of carbon, requiring nominally 2.67 lbs. of oxygen or 11.52 lbs. of air per 1 lb. of carbon (or a total of 16,300 lbs. of air) for perfect combustion to CO_2. One pound of air at 70 deg. Fah. occupies about 13.3 cub. ft., so that the quantity of air at atmospheric pressure required per hour would be 216,800 cub. ft. This conforms very well with the generally accepted figure of 30,000 cub. ft. of air per ton of iron melted per hour.

It is presumed, then, that the cupola must be supplied with, say, 217,000 cub. ft. of air per hour, distributed regularly throughout the coke at one or more levels. The simple delivery into the cupola of that amount could be obtained by various combinations of *area of conduits* × *density of air* × *velocity of current*, and it is here that some of the previously-mentioned considerations come into play. It will be obvious that equable distribution *round the periphery* of the cupola can best be obtained by a continuous or sheet tuyere, or next best by many tuyeres closely set, and, taking a continuous tuyere, the quantity would govern the depth of the tuyere and the velocity of the current to be employed. Thus, with a 48-in. dia. cupola a continuous tuyere would have one dimension (length) 150 ins. From accepted data can be found the quantity of air which an opening 1 ft. sq. can deliver at varying pressures. It is thus a simple matter to calculate the tuyere area necessary to deliver 216,800 cub. ft. of air per hour (or 3,614 cub. ft. per min.). If the tuyere were made 1 in. deep, giving an orifice of approximately 1 sq. ft., a pressure of 0.9 in. water gauge would be sufficient; while a pressure of 8 in. w.g. would be required to introduce the same air through the tuyere were it only ¼ in. deep, and if only ¼ in deep about 16 in. w.g. would be required. These figures are based on air at 32 deg. Fah.; for 70 deg. Fah., or about atmospheric temperature, the capacity of the conduits would be slightly less if considered on the basis of weight of air.

It will be interesting to compare the tuyere area thus arrived at with those recommended by different writers:—

(1) McWilliam and Longmuir: A 44-in. cupola, 6 tuyeres at 6 in. dia. = 170 sq. in. tuyere area, and 9 oz. pressure (= about 14 in. w.g.). This tuyere area, after making due allowance for extra friction by reason of the multiplicity, would be equivalent to little more than one 12-in. dia. main and less than 1 cub. ft. effective. Nevertheless, these tuyeres and pressure should be able to deliver to atmosphere about 14,000 cub. ft. of air per min., whereas the amount required for the cupola would appear to be about 3,600 cub. ft.

(2) West recommends for a 48-in. cupola seven tuyeres at 5½ in. dia. = 166 sq. in., or about 110 sq. in effective tuyere area. He also states that the blast pressure will vary from 8 to 20 in. w.g. Even at 8 in. w.g. these tuyeres should be able to deliver nearly 8,000 cub. ft.

The deduction is, then, that the pressure is largely absorbed in other directions than the mere delivery of air, and is, therefore, no indication at all of the quantity passing. A moment's consideration will explain this. Were the tuyeres discharging to atmosphere the theoretical quantity would be delivered, but directly the resistance of the cupola charge is met the recorded pressure increases, though the quantity delivered may remain the same. The pressure-gauge rise, then, records the resistance to the entry of the air and not the amount entering. The latter can only be calculated by ascertaining both the pressure (density) and the velocity (rate of travel). In other words, the figures of velocity in relation to pressure quoted above do not give much useful information for cupola working. What the foundryman requires is a velocity recorder to register the *rate of travel* at any point on the system. This, in conjunction with a pressure gauge at the same point recording the *density* of the blast, would allow a direct calculation of the *weight* of air passing. To simplify the calculation and allow direct reading, also, the pressure gauge should be set out in

density factors direct and not in inches of water. This factor could then be multiplied direct with the velocity factor to determine the weight of air passing.

Pressure Gauges.

So far as the record of the pressure gauge on the blast main is concerned, this may be denounced at once as hopelessly unreliable. In the first place, the pressure recorded in the main bears no relation to the volume passing through the tuyeres. The pressure so recorded is the product of the velocity of the current and the resistance to its passage offered by the conduit and discharge point. It might be calculated that a given area of blast main working at a given pressure would deliver a fixed quantity of air per period, but this, as stated, would involve discharging to atmosphere, and not against variable or indefinite resistance.

With a blower delivering a fixed quantity of air per revolution, the pressure recorded by the gauge is only a measure of the friction in the conduits and the resistance of the stock. With a fan it is a measure of the same factors but in different ratio. In neither case, however, does the pressure gauge record the *quantity*, of air passing, but merely its state of compression or density at the point of reading. With an unvarying resistance the pressure, of course, can be used as a means of recording the quantity, but since the resistance in cupola blowing varies continuously, the pressure is a guide to quantity only when the rate of travel has also been determined. With a fan the delivery may cease altogether, and the pressure still rise.

Possible Methods of Measuring.

Considering now the possible methods of measuring the velocity of flow of air through the blast main, it should be remembered that this will not be uniform across the whole sectional area of the pipe. Experience has shown that the centre of the stream flows at a greater rate than does the portion nearest the wall. For experimental work a mean figure can be obtained from careful measurements across the whole sectional area. The difference results probably entirely from the frictional effects of the tube or conduit sides, which causes a rolling, and hence slower movement than is allowed in the centre, where the only frictional effect is that of the air molecules on each other. For practical purposes, however, it is not generally necessary to arrive at very fine accuracy of measurement. If readings are taken at any given point, and the figure associated with best results at the cupola end is ascertained, it does not matter what that figure is in numerals so long as it is maintained in that position during working operations.

Probably the simplest method of reading air speeds is by means of the pitot tubes and manometer gauge, using the formula:

$$V = 58.9 \sqrt{H}$$

where V = velocity of flow in feet per second, and H = inches water gauge.

The reading, of course, requires correction for density of the air, which varies with both pressure and temperature. In the accompanying chart, Fig. 3, are set out curves for the ready calculation of this.

An alternative method, when greater accuracy is required, is to use a Venturi tube and measure the change of pressure between the entrance and throat, the formula then being:

$$\text{Lbs. air per min} = 541 \times \sqrt{\frac{H \times P}{T}}$$

where H = pressure difference between entrance and throat in inches water gauge; P = *absolute* pressure of air in pipe in lbs. per sq. in. (which takes into account the height of the barometer); and T = *absolute* temperature of air in pipe in degrees Fahr.

This latter was the method used in Mr. Cook's experiments.

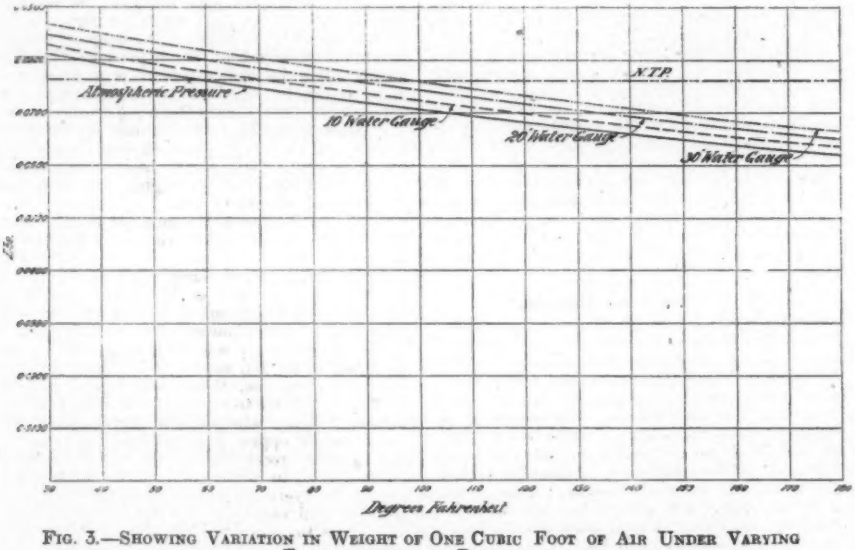


FIG. 3.—SHOWING VARIATION IN WEIGHT OF ONE CUBIC FOOT OF AIR UNDER VARYING TEMPERATURES AND PRESSURES.

Multiplicity of Tuyeres.

When arranging the ratio of tuyere area to cupola sectional area, it is important to avoid the mistake of assuming that the blast from a single main can with the same power be discharged at the same rate through a number of tuyeres having a total cross-sectional area equal to the sectional area of the main. A blower will discharge at a rate, for example, sufficient to pass 20,000 cub. ft. of air through a 17-in. dia. main at 6 ozs. per sq. in. pressure; but in dividing this volume of air between, say, 10 tuyeres of 5⅛ in. dia. (giving a total area of 227 sq. in., or the same as for the main) there is involved a loss by friction. This

will be readily understood when it is recalled that while one pipe 17 dia. has a circumference of 53.4 in., 10 pipes 5⅜ in. dia, have each a circumference of 16.88 in., or a total of 168.8 in. The tuyere area must accordingly be greater than that of the blast main to carry the same quantity of air.

Function and Effect of Velocity.

Having first installed a blower and main that will deliver the maximum quantity at the minimum velocity, we find that the pressure actuating the current has to be increased to overcome the resistance of the stock in the cupola, or, in other words, the reduced area of passage and increased friction encountered. The power input of the blower must therefore be increased to create the pressure. This increase in pressure must, of course, be proportional to the resistance to maintain the desired rate of flow, and as the reduction of passage area and increase in friction cannot be ascertained properly, the rate of flow through the main must be maintained. But as the pressure increases the density of the air increases, and hence the actual weight of air for a given rate of travel increases. According to Boyle's Law, the density of air is proportional to its pressure for the same temperature. Atmospheric pressure is 14.7 lbs. (235 ozs.) per sq. in. For each 1 in. water-gauge (or 0.578 oz. per sq. in.) of pressure, then, the density of the air would be increased by 0.00245 atmosphere. From the table in the appendix it will be seen that the relative increase in density with increase in pressure is very small, and that the chief function of increased pressure is to overcome resistance in the cupola and increase the rate of flow in keeping with the reduction in passage area caused by the stock, blocking of tuyeres, etc. Until the latter factors can be measured, however, the pressure gauge does not act as a quantity indicator, though if the quantity passing be known accurately the pressure gauge does indicate the resistance which has been overcome and the probable velocity of entry.

The function of pressure expressed as velocity is the penetration of the stock and distribution through the cupola melting zone, and this velocity is determined by the size of the tuyeres in relation to the quantity of air passing.

It would appear that the actual area of the main conduit is not of vital importance, provided it is not below well recognised practical limits, and that the real necessity is to ascertain that the right amount of air is actually passing. To test the matter the pressure at the mouth of the blower discharging the desired quantity to the atmosphere should first be gauged, next the pressure at the tuyeres when the same quantity is being delivered. The relative increase in recorded pressure would show the pressure absorbed by the system. Any form of gauge that would then record the rate of flow at any given point in the system would enable the efficiency to be checked, as the requisite rate of flow with an empty cupola could be easily ascertained, and if with a full charge it decreased, then the pressure would have to be increased until the rate of flow came up to requirements; and the pressure (recorded at the same point as the rate of flow) would be used to determine the density of the flow, and for correcting that reading for the weight. For example :—If the rate of flow is 60 ft. per sec. at 2 in. w.g. operating on an empty cupola, and the pressure is increased to 16 in. w.g. to maintain the rate of flow as recorded, the density would be increased by 0.0344 atmos., and thus the actual rate of flow would be $60 + (60 \times 0.0344) = 62.064$ ft. per minute.

It may be concluded that when the amount of air to be introduced has once been determined the two chief variables in working are (1) the area of passage into the cupola, i.e., the tuyere area when the furnace is working freely, and (2) the velocity necessary to transmit the determined quantity through that area, which is determined by the pressure if the quantity is actually passing. The question to be solved first by the founder is the necessary quantity of air per minute; and then he has to decide on that combination of tuyere area and pressure which will best meet his requirements. To maintain the flow of the desired quantity the tuyere area may be decreased and the pressure increased, or *vice versa*; but with decreased area and increased pressure the velocity of the current entering the cupola will increase. The necessity of keeping down the velocity to the lowest point which will serve to penetrate to the centre has been discussed already, and can only be determined by experiment; but it is reasonable to assume that the better the distribution round the periphery of the cupola the better will be the chance of a low velocity performing its function properly. Theoretically, the sheet tuyere should be the best, but separate tuyeres in a ring are in practice more readily watched and kept clear from obstruction, while giving practically the same effect as a sheet tuyere.

A complication which arises in actual working is the slagging up of the tuyeres as the blow proceeds. This, in many cases, is quite an appreciable factor, for it reduces the amount of air that can pass for a given pressure. If the slagging merely caused a gradual contraction of the tuyere through its length it would be of minor importance, since then decrease of area would be compensated by increased velocity, volume remaining unchanged. But the rule Volume = Pressure by Area, or $(+ P - A)$ or $(- P + A)$ does not apply when the orifice is suddenly obstructed. The importance of a volume recorder is here again emphasised, as it would act as an indicator of tuyere obstruction.

The writer is well aware of the difficulty in practical working of keeping constant the area of tuyere orifice; but were the cupola man given a ready means of gauging the reduction in air volume passing which results therefrom, he would be better able to reduce the variation to a reasonable amount by giving it attention at the proper time. With a correctly proportioned blower, delivering a constant and positive quantity of air, rise in pressure alone indicates tuyere obstruction, and in practice such rise is often interpreted in that sense; but few blowers operate with sufficient nicety under conditions of increased resistance to act as volume recorders. Foundries are not noted for care in the maintenance of such apparatus, and it is common to find quite excessive slip in the blower, increasing abnormally with increase of resistance.

Horse Power for Maintaining Flow of Air.

It is often necessary to determine the horse-power required to maintain a flow of air of a given velocity. Were the resistance merely that of air movement, exclusive of conduit and other resistance, the following formula would give the result :—

$$\text{AHP} = \frac{5.2 \times P \times V \times O}{33{,}000}$$

Where AHP = air horse-power; O = orifice area; V = mean velocity of air in feet per minute; and P = water-gauge reading in inches.

This is, of course, based on the fact that 1 in. air pressure, as shown on the water-gauge, is equal to 5.2 lbs. pressure per sq. ft., so that the water-gauge reading multiplied by this figure and by the velocity of air passing per minute, and the area of discharge, gives foot-lbs. per minute. The resistance of the conduits (frictional) and the resistance at the discharge point, however, complicate the calculation—so much so that the writer knows of no formula that will apply to cupola systems generally, owing to the differences in resistance at the discharge ends. When the pressure necessary for maintaining the velocity or rate of flow has been determined, the above formula would apply, taking O as representing the diameter of the conduit at the point of pressure measurement. The correction for resistance due to length of conduit and other causes would then be absorbed in the revised P factor.

Relative Volume and Weight of Air at Varying Temperatures.

Temperature. Deg. F.	Volume of 1 lb. of air.	Relative volume.	Weight of 1 cub. ft.
	Cub. ft.		Lbs.
32	12.36	1.000	0.0807
40	12.59	1.016	0.0795
50	12.80	1.036	0.0778
60	13.05	1.056	0.0763
70	13.30	1.076	0.0748
80	13.55	1.097	0.0735
90	13.80	1.117	0.0722
100	14.05	1.137	0.0710
110	14.30	1.157	0.0696
120	14.56	1.178	0.0684
130	14.81	1.198	0.0673
140	15.05	1.218	0.0661
150	15.31	1.239	0.0651
160	15.56	1.259	0.0640
170	15.81	1.279	0.0630
180	16.06	12.99	0.0620
190	16.31	1.320	0.0611
200	16.56	1.340	0.0601

Density of Air at Varying Pressures and Normal Atmospheric Temperature.

Inches. Water gauge.	Ounces Pressure Per Square Inch,	State of Compression in Atmosphere.	Relative Volume of 1 lb. of Air
0	0	1.00000	1.00000
1	0.578	1.00245	0.99754
2	1.156	1.00491	0.99511
3	1.734	1.00737	0.99268
4	2.312	1.00982	0.99026
5	2.890	1.01228	0.98786
6	3.468	1.01474	0.98547
7	4.046	1.01720	0.98309
8	4.624	1.01965	0.98072
9	5.202	1.02211	0.97836
10	5.780	1.02457	0.97601
11	6.358	1.02702	0.97368
12	6.936	1.02948	0.97136
13	7.514	1.03194	0.96904
14	8.092	1.03440	0.96674
15	8.670	1.03685	0.96445
16	9.248	1.03931	0.96217
17	9.826	1.04176	0.95990
18	10.404	1.04422	0.95764
19	10.982	1.04668	0.95539
20	11.560	1.04914	0.95316
21	12.138	1.05159	0.95093
22	12.716	1.05405	0.94871
23	13.294	1.05651	0.94651
24	13.872	1.05896	0.94431
25	14.450	1.06142	0.94212
26	15.028	1.06388	0.93995
27	15.606	1.06633	0.93778
28	16.184	1.06879	0.93563
29	16.762	1.07125	0.93348
30	17.340	1.07371	0.93135

Conclusions.

The conclusions from the foregoing are as follows :—

(1) The variables in cupola operations are so numerous and indeterminable under practical conditions that general formulæ relating to blast pressure, volume, rate of melting, fuel consumption, etc., are not practicable; though for any given plant in which the nature of coke used, methods of charging, etc., are fairly constant, an approximate formula may be deduced from experiments, and will apply with reasonable consistency. It will not necessarily, however, apply to another plant with equal accuracy.

(2) The prime essential in any investigation of cupola operation and efficiency is a means of indicating the actual weight of air delivered to the cupola, in addition to the velocity of delivery; and this does not require to be an indicator of scientific accuracy as to *absolute* weight so much as an indicator of relative variation in weight, in order that a given weight (whether its absolute value be strictly known or not) may be maintained constant or definitely varied during experiments.

(3) Investigating experiments should take the form of (*a*) variations in weight of air with constant tuyere area, involving varying velocity, (*b*) variations in weight of air with constant velocity, involving varying tuyere area, (*c*) variations in velocity with constant weight, involving varying tuyere area.

There are obvious practical limits to each required variation, and a few judicious preliminary experiments can easily be made to narrow the field of close investigation to reasonable proportions. For example, known chemical law sets the lower limit for weight of air; chilling of the metal and over oxidation set the upper limits to velocity; while structural consideration and the periphery of the cupola limit the tuyere area, particularly since excessive depth of combustion zone is undesirable in the light of considerations before enumerated.

(4) Pressure of blast in itself is of no significance in the abstract. It only becomes an indicative factor when taken in conjunction with velocity or rate of travel to determine weight of air passing. Pressure does not necessarily indicate either volume passing or velocity of entry.

In conclusion, the author considers that it is quite reasonably possible by experiments with any normally constructed cupola to establish conditions of operation which would secure a 1 : 14 ratio of fuel consumption to iron melted (excluding bed coke), and that such experiments would not be disproportionately expensive if intelligently conducted.

(*For discussion on this paper see page* 434).

BRITTLENESS OF ELECTROPLATED STEEL.—According to Mr. T. S. Fuller, writing in "The Iron Trade Review," one of the serious problems which confronts the makers and users of non-corroding steel springs is the brittleness produced during electroplating. The facts are all in accord with the assumption that the absorption by the steel of atomic or nascent hydrogen liberated at the cathode in the plating bath is the cause of this embrittlement. This may be prevented by first dipping the springs in a bath of molten tin. The tin forms a coating on the steel which is impermeable to atomic hydrogen. Rosin may be used as a flux in the tin-dipping. The springs may be sand-blasted, but must not be pickled in acid. Steel springs may be dipped in molten tin at a temperature of 260 to 300 deg. Cent. without appreciably changing their mechanical properties. The spring thus coated with tin can then be copper-plated without risk.

OCCLUDED GASES IN FERROUS ALLOYS.—Professor Gellert Alleman and Mr. Charles J. Darlington, in a Paper dealing with the results of experiments specially undertaken by them and others in the laboratory of Swarthmore College, Pa., U.S.A., thus summarise their conclusions :—(1) They have constructed a gas-tight vacuum furnace capable of continuous service at temperatures of about 1900 deg. C. (2) By means of this apparatus all the gases occluded in ferrous alloys may be removed and collected. (3) It appears that the gases are evolved in the following order : Hydrogen is most readily set free, carbon monoxide comes next, and nitrogen seems to be held most tenaciously. (4) Whether oxygen is the result of the decomposition of various oxides of iron or the dissociation of carbon monoxide or dioxide has not been determined. (5) They have shown that ferrous alloys may occlude relatively large volumes of gases —in some cases equal to about 200 times the volume of the metal. (6) They suggest that in addition to the ordinary functions of metals like aluminium, tungsten, chromium, manganese, titanium, silicon, etc., when placed in ferrous alloys, these elements may act as a catalytic agent and either prevent the occlusion of large quantities of gases or aid in the elimination of such gases at lower temperatures than would ordinarily take place. (7) They have shown that the removal of gases from ferrous alloys markedly changes the micro-structure and increases the density of the alloy.

Stobie 15-Ton Electric Furnace.

The arc type of electric furnace can be divided into two classes, *i.e.*, (1) small furnaces, to include those up to six tons, and (2) the large class from seven tons upwards. It is necessary to so differentiate, because the ratio of the weight of the structure to the weight of the charge in small furnaces may be as high as six to one, whereas with the large furnaces it is often down to as low as three to one. In other words, with small furnaces a large proportion of the heat must be employed to keep the fabric hot, and for this reason it is often found advantageous to heat separately the hearth of the furnace at the same time as the charge is being heated, so as to negative the abstraction of the heat from the molten bath by the hearth and prevent chilling of the bottom layers of steel. Especially when dealing with high-percentage alloy steel is this of vital importance, as unless a uniform temperature is obtained throughout the mass, any of the alloys at the bottom of the furnace will tend to remain there on account of their greater specific gravity when cold than when hot.

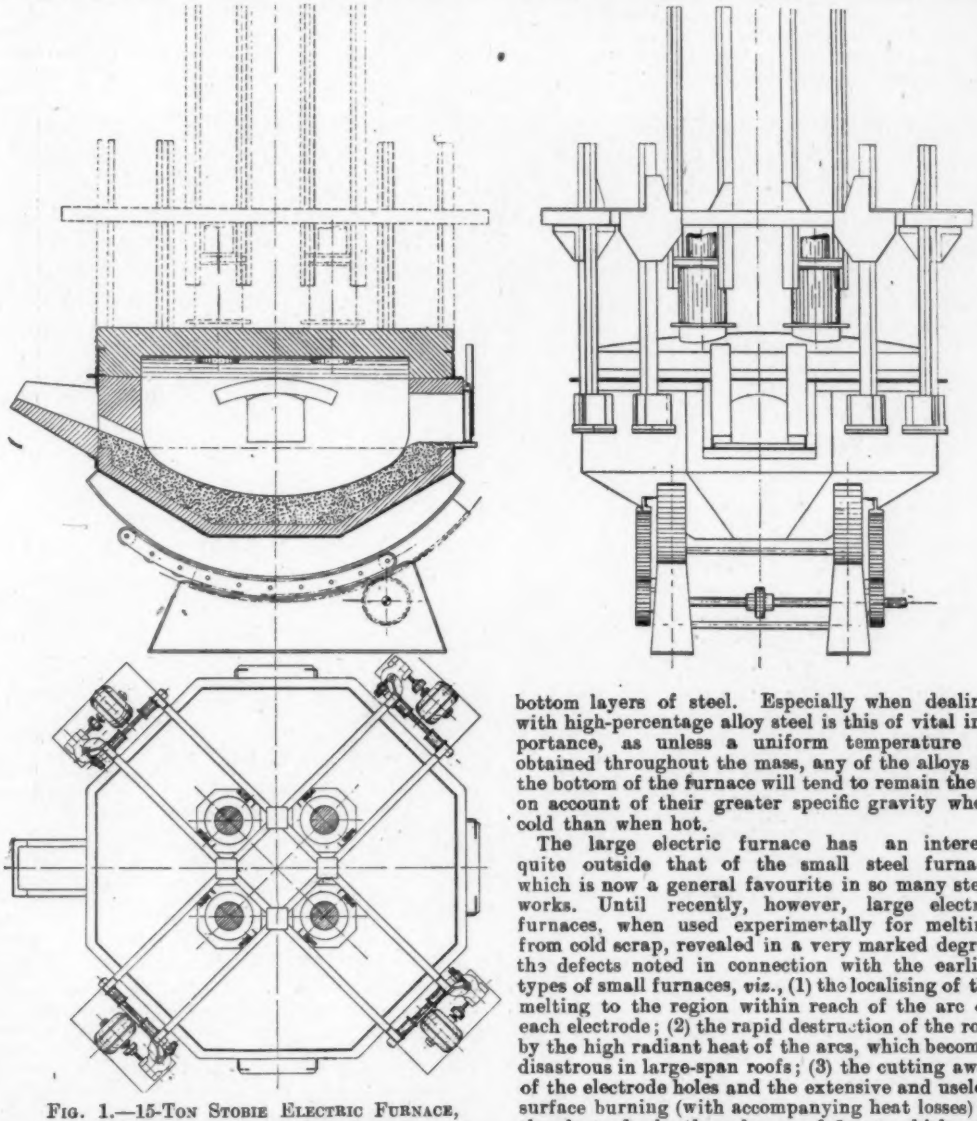


FIG. 1.—15-TON STOBIE ELECTRIC FURNACE, SHOWING ELECTRODE ECONOMISERS.

The large electric furnace has an interest quite outside that of the small steel furnace which is now a general favourite in so many steel works. Until recently, however, large electric furnaces, when used experimentally for melting from cold scrap, revealed in a very marked degree the defects noted in connection with the earlier types of small furnaces, *viz.*, (1) the localising of the melting to the region within reach of the arc on each electrode; (2) the rapid destruction of the roof by the high radiant heat of the arcs, which becomes disastrous in large-span roofs; (3) the cutting away of the electrode holes and the extensive and useless surface burning (with accompanying heat losses) of the electrodes by the columns of flames which gush out of the electrode holes in the roof; (4) the rapid tapering of the electrodes within the furnace, due to oxidation by the air drawn in through the doors as a result of the chimney effect of the last-mentioned defect; (5) the phenomenally quick loss of heat by the furnace after tapping, resulting from the hurricane of cold air which flows through

the furnace doors and out of the electrode holes the moment the doors are opened for fettling and charging.

It will be seen that each of these defects arose from the impossibility of stopping up the gaps around each electrode where the latter passes through the roof. Obviously, as the large volumes of flame pass out through the gaps, equally large volumes of air are sucked into the melting chamber. Ever since the introduction of the electric furnace attempts have been made to overcome this trouble, because the seriousness of the losses threatened to prevent electric steel ever becoming cheap enough to compete with the higher grades of Siemens steels. An important improvement has recently been devised by Mr. Victor Stobie whereby an electric furnace can be completely sealed up, notwithstanding the number of gaps in the roof; to this we shall refer later.

Before describing the furnace which our representative saw in operation at the Dunston Works of the Stobie Steel Company, it may be interesting to consider the commercial possibilities of the large as compared with the small electric furnace. A well-designed electric furnace is very efficient thermally, and a medium-sized furnace of, say, six tons will melt steel on little more current consumption per ton of steel than one of double that capacity. It is on the basis of reduced capital costs, labour, repairs, and electrode consumption that the large furnaces are claimed to be much cheaper to operate. For instance, the extra costs per shift of working a 15-ton over a 5-ton furnace are, to-day, approximately as follows:—

	£	s.	d.
Two extra helpers at 8s.	0	16	0
Extra electrodes, 160 lbs. at 9d.	6	0	0
Extra repairs	2	0	0
Extra capital charges	1	7	0
	£10	3	0

From the above it will be seen that, excluding the cost of the extra raw materials and current, four 15-ton heats of steel may be manufactured for the same total cost as four 5-ton heats of steel, plus £20 6s. If we take the cost of making, in a 5-ton furnace, four 5-ton heats of steel in 24 hours, including raw materials, current, labour, repairs, electrodes and capital charges, to be, under present conditions, £10 per ton, the cost of making 20 tons of steel will be £200. With a 15-ton furnace the cost of four heats, or 60 tons, of steel will be:—

	£	s.	d.
Cost of 20 tons in 5-ton furnace	200	0	0
Extra cost as detailed above..	20	6	0
Extra 40 tons of scrap and current	213	10	0
	£433	16	0=
	£7	4s.	7d per ton.

If we figure on a 30-ton furnace the cost of

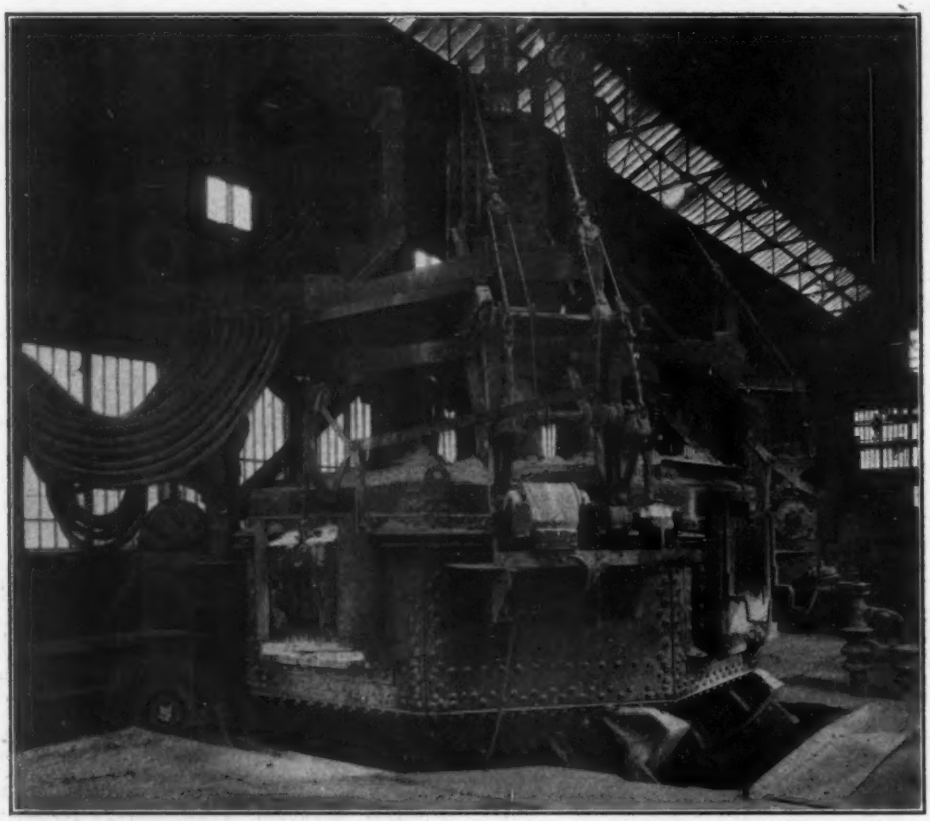


FIG. 2.—15-TON STOBIE ELECTRIC FURNACE IN OPERATION.

labour, scrap, repairs and many other items are very sensibly altered from the basis of rates obtaining on small furnaces. On such a furnace the total labour would not cost more than that on a Siemens open-hearth furnace, namely, 2s. 4d. per ton basis. Such a furnace would utilise cheaper types of steel

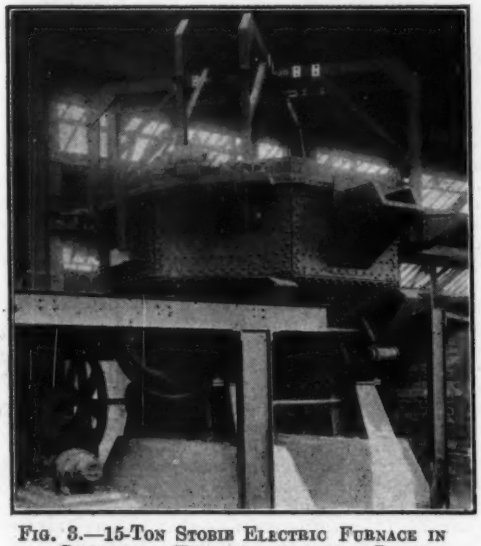


FIG. 3.—15-TON STOBIE ELECTRIC FURNACE IN COURSE OF ERECTION, SHOWING ROLLER TILTING GEAR.

scrap. It would give double the number of heats per week that are obtained from a 30-ton Siemens furnace, and would occupy one half the area. Assuming pre-war conditions (for the sake of easy comparison) the cost of making four heats of steel in a 30-ton electric furnace would be as follows:—

	£	s.	d.
Scrap, 123 tons at £2 5s.	276	15	0
Current, 72,000 units at 0.4d.	120	0	0
Electrodes, 900 lbs. at 5½d. per lb.	20	12	6
Labour, at 2s. 4d. per ton	14	0	0
Slag materials	0	10	0
Additions (Fe-Mn ; Fe-Si)	18	0	0
Repairs at 4s. per ton	24	0	0
Tools	2	0	0
	£475	17	6=
£3 19s.	4d.	per	ton.

In view of the considerably reduced cost of operations, the question therefore arises why are the large electric furnaces not more favoured for melting from cold scrap? The answer is that on the Continent and in the United States large furnaces have given causes for dissatisfaction in regard to electrode consumption, life of roof, and speed of work. Such large furnaces as do exist abroad (with one exception) have been installed to receive liquid steel charges from Bessemer or Siemens furnaces. The use of liquid charges tends to more uniform temperature and treatment in the furnace, yet the results obtained have not encouraged the quick growth of such installations, possibly because the duplexing of steel in such a manner would rarely be as cheap as the direct manufacture of steel in large furnaces.

The 15-ton furnace seen in operation by our representative at the Stobie Steel Works is the largest electric furnace in this country. Of the structure itself little need be said; this, as also the disposition of the electrode motors, is shown in our arrangement illustration (Fig. 1), whilst the roller-tilting gear—a unique feature—is clearly shown in our view of a furnace under construction (Fig. 3). By this gear, which is driven from a 15-h.p. motor, the furnace is tilted towards the platform for slag removal, an opening in the platform permitting the discharged slag to fall to the shop floor level into a bogie for removal. The same mechanism tilts the furnace in the reverse direction for tapping.

The furnace is a three-phase, as indeed were the majority of the early types of large arc furnaces. (Mr. Stobie, however, is now building mainly two-phase four-electrode furnaces.) Of the earlier types, one was mesh-connected and another star-connected with one phase reversed, the effect of this reversal, however, has not been published by the users. The large Stobie furnace is free of all such complications, being an ordinary star-connected one. The three phases are each connected to an electrode above the bath, and the central point of the star connection is carried to another electrode, also above the bath. The object of this device is to avoid, as far as possible, any overloading of the conductors or fluctuations in the electrical conditions, and to give a better distribution of heat over the surface of the metal. This is accomplished by the fourth electrode above the bath taking the unbalanced currents in the furnace, instead of each phase-electrode being burdened continually with the unbalanced currents in the other two phase-electrodes. The serious overloading of cables and electrodes in most types of 3-phase furnaces will be understood when it is remembered that any phase-electrode may be already seriously overloaded when

FIG. 4.—STOBIE FURNACE POURING; ILLUSTRATING "DEADNESS" OF METAL AND GOOD EFFECT OF ELECTRODE SHIELDS.

it is called upon additionally to carry its share (50 per cent.) of an overload taking place simultaneously on one of the other phases. With the Stobie arrangement the fourth electrode is obliged to take all unbalanced current, and its chance of being overloaded is nil.

The principle of the Stobie furnace is as follows:—Three electrodes above the bath are connected to the three phases of a four-wire star-connected supply, whilst the fourth electrode is connected to the middle or neutral point of the supply system. The electrode arc gaps above the metal are adjusted according to the phase and inter-linked pressures. Any reduction in the resistance of the arc gaps under one of the three-phase electrodes will reduce the resistance of the phase circuit by a greater percentage than it will reduce the resistance of the inter-linked circuit; therefore, excess current is taken by the fourth or neutral electrode. Obviously, when a three-phase electric furnace is working the phases are never balanced, owing to the constant movement and fluctuation in the resistance of the material which is being melted and the "waviness" of the surface of the bath when molten, so that the neutral electrode will constantly carry current and do its share of the heating or melting of the charge.

FIG. 5.—STOBIE FURNACE; POURING INGOTS.

As regards electrode consumption, the major portion of it does not take place at the arcing points, but results from the surface burning of the carbon all over those parts of the electrode which are inside the melting chamber and up to a point about 12 in. above the roof, and it will be well within the mark to say that from 50 per cent. to 70 per cent. of the heavy expenditure on electrodes is wasted through this defect. Various attempts have been made to eliminate the evils arising from this, not the least of which is roof cutting, which incidentally serves to destroy the chemical reducing atmosphere within the furnace, because, as already stated, the outgoing flames through the electrode holes suck in cold air and introduce an atmosphere into the furnace which burns away the surface of the carbons. This is made evident when those portions of the electrodes within the furnace are examined, as they are found to be tapering down considerably from the point where they enter the furnace chamber to the arcing point. Amongst many devices employed to remedy this defect, which is of more serious moment in the large furnaces, mention may be made of a method of (1) enveloping the carbons with asbestos paste held in position with wire-netting, (2) coating the electrodes with non-burning paints, and (3) surrounding the electrodes with water-cooled cylinders extending well inside the furnace. With regard to (1) this is very expensive to apply and quickly perishes within the melting chamber; in (2) the non-burning coatings all expand and fall away from the non-expanding electrode, and in (3) the internal water jackets are most wasteful of heat, are ineffective, and a source of danger within the furnace. A modification of the last-mentioned method provides for making the water-coolers round the holes a sliding fit round the electrodes; this, of course, demanded that the electrodes must be turned to size—a most expensive detail when amorphous electrodes are used, apart from the fact that such an arrangement would only delay for a few hours the evil it was designed to overcome. The parts of electrodes inside the melting chamber become white-hot. Every time an electrode is raised—a constant operation—some white-hot or bright red-hot part of the electrode will be raised into the air above the furnace roof and burn away at the surface to a smaller or greater extent, and thus in time give clearance for the passage of flames. In the Stobie furnace the evil has been eliminated in a remarkably simple manner. Observation showed that at one or two feet above the roof in most electric furnaces, the electrodes, even when raised high for charging, are seldom at a temperature at which they can burn; therefore that is the only point at which a permanently good seal can be made round the electrodes. It is only necessary to enclose hermetically an electrode from the roof up to that point to prevent its burning away, and the consequent escape of the heated gases from the furnace.

For this purpose Mr. Stobie provides a light metal cylinder a few inches larger in diameter than the electrode, and about 2 ft. in length, which is fixed on to the roof round each electrode. A sealing of fireclay is made where the bottom of the cylinder meets the roof, and the top end of the jacket is covered with a sealing plate which prevents the passage of the flames, the electrode passing through a neatly fitting hole in the centre of the cover plate. In effect this improvement has accomplished far more than one would expect from so simple a device, and it may be well worth while to consider the results of its application in detail.

(1) As there is no chimney effect no cold air is drawn into the furnace.

(2) Practically all surface combustion of electrodes is arrested.

(3) A really reducing, carbon depositing (when desirable) atmosphere is constantly present within the melting chamber.

(4) The entire original sectional area of the electrodes is available for current carrying, as they do not become pencil-pointed. The electrodes may therefore be of much smaller diameter for a given current supply. In addition to cutting down electrode costs, this permits a reduction in the size of electrode holes in the roof, and thus strengthens the roof.

(6) There is no heat loss, and therefore no waste of current from escaping volumes of flame, while

at the same time there is a corresponding increase in speed of work.

(7) Heavy carbonaceous vapours in the furnace act as an opaque pall between the heat from the arc and the roof, thus reducing cost of repairs to both roof and lining.

(8) Electrode holders and gear keep cool without water-coolers.

(9) Cooler working conditions exist for the furnace hands and the melting shop generally.

(10) After tapping, the heat is retained in the furnace just the same as in the open-hearth furnace. This considerably reduces the fluctuations of current on starting, preserves the lining, and speeds up the melting.

It is claimed that a large electric furnace with the Stobie economisers attached can produce best-quality steels at the same price as an equal-sized Siemens furnace, and the product is, of course, well known to be more perfect in finish and composition than the best open-hearth furnace steels.

At the time of our representative's visit to Dunston one 15-ton Stobie furnace was making nickel-chrome steel in six hours from tap to tap—in fact, the books show that there is a regular output of 24 heats per week. The actual life of the roof has not really been determined, output at the moment is the vital necessity, and no risks are therefore taken, the roof being replaced every third week.

The current consumption per ton of saleable ingots (nickel-chrome steel) varies from 600 to 625 units. The actual loss is 2½ per cent. of the total metal charged. In considering this it may be mentioned that the furnace cannot at present be worked under the best conditions as regards charge; designed for an output of 15 tons, owing to the shop crane capacity it is only possible to melt charges up to 10/11 tons. That the operation of the furnace has been consistently good is evidenced by the output. In June, 1916, this was only some 150 tons per month; for the same month of 1917 the output was 600 tons, whilst in July of the same year the output had been increased to over 1,000 tons, a figure which has since been maintained.

In pre-war days the furnace was regularly producing high-speed steel, 25 per cent. nickel steel, 14 per cent. chromium steel, and 13 per cent. manganese steel. It is also interesting to note that the world's record of 10-ton charges of high-speed steel is held by this plant.

We understand that two new 15-ton furnaces have recently been put into commission. Designs have been made for a 30-ton furnace fitted with the Stobie economisers, but the Minister of Munitions has vetoed this addition for the moment, although the inventor claims that 60-ton 'ectric furnaces are feasible provided they are fitted with economisers. In this connection it is claimed that the Stobie type of economiser can be applied to all existing types of electric furnaces and will effect the previously-mentioned economies, estimated at between 30s. and 40s. per ton of steel manufactured.

We hear that a Stobie furnace which will rank, along with those at Dunston, as the largest in Great Britain, has recently been ordered by Sir W. G. Armstrong, Whitworth & Company, Limited.

THE governing body of Sheffield University have conferred honorary degrees on Sir W. H. Ellis (Doctor of Engineering), and Mr. G. Blake Walker (Master of Engineering).

Foundry Problems.

At a recent meeting of the Newcastle and District Branch of the British Foundrymen's Association a Paper on "Some Foundry Problems" was read by Mr. J. Shaw, of Dudley. Mr. W. Mathews, the president, occupied the chair. The Paper has already been published in abstract in our columns. The discussion was as follows:—

THE PRESIDENT said that foundrymen were sometimes called upon to make castings which cost the foundry a good deal of anxiety and money. Sometimes they took on difficult work of that description without making any protest or without making any suggestions to the people who wanted the castings made. With regard to test bars he thought they should be graded according to the sections of the castings. A chemist's analysis was not everything, and one wondered whether the conditions of the blast furnace stood for all time. They had heard such strange terms as "heredity" used by one protagonist in connection with cast iron. There were certain physical characteristics which persisted in cast iron, and it was desirable to know why irons of similar chemical analysis sometimes behaved differently under test. In foundry equipment Great Britain seemed to be very far behind both America and the Continent, and even without being unpatriotic one should not be above taking a leaf out of the German book.

MR. MATTHEW GALLON said he was struck by a remark which Mr. Shaw had made with regard to the Germans taking more notice of what was done in the machine shops than what was done in the foundry. Care as to the method of getting the casting into the machine might be of more importance than attention as to how a job was to be moulded; but if they were to save the engineer expense in the fitting shop he thought they should be remunerated for the extra trouble they had in making the casting. In other countries foundries got pig metal which they could readily break. In fact, in America some of it had not to be broken at all, but in this country it took a gladiator—sometimes two gladiators—to break it. They should tackle that sort of thing and get the makers to make pigs which the men would not have to break at the expense of breaking their own backs.

MR. HENDERSON, with reference to illustrations of Continental foundries that had been shown, asked how they compared with foundries in our own country, making allowance for the fact that we were a comparatively old country in the foundry industry.

MR. J. D. CARMICHAEL said most of the foundries on the Continent were attached to engineering works and under their own management. Our difficulty here was competition, and the other fellow coming in to have a try to see what he could get out of it.

MR. J. SMITH said the foundries abroad were well equipped as far as the saving of labour was concerned, but the question did not end there. The most important thing they wanted to consider was, what were the castings like, and what did they cost in comparison with the English casting? He had occasion to be on the Continent a few years ago and he went into an engineering works where they were building marine engines. He there saw three condensers which had come out of a large foundry in Germany—one of the largest places in Germany—and they were three

"wasters." There would have been trouble if a founder had finished work like that on the North-East Coast. They asked whether the English could make a better casting on the North-East Coast. They wanted to know the cost, and he told them, and they gave him an order for a casting. It was sent over to Germany, and after that he could have had as much work as he liked from the same firm. They afterwards allowed the German foreman to look through their shop. The man came over and saw a bedplate cast before he went out of the place, and he was astounded at the way in which our men got through their work and the excellence of the work they turned out. Despite all the beautiful machinery in the Continental foundries, British foundrymen could do better as far as quality of work in cast iron was concerned. They could do better than the Germans. Foreign Governments had subsidised their foundries, but if the British foundries were subsidised in the same way, and they turned out the same kind of work, they would be kicked out of the place and their subsidies stopped.

Another member said he had had the same experience as Mr. Smith with regard to Continental foundries. The Germans had tried to make some of the greatest castings for ships which were now in the Kiel Canal, but although they had several tries they did not succeed. It was his opinion so far as production was concerned that the Germans could not touch us. With regard to reciprocity of visits, the Germans had often been pleased to see British foundrymen in their midst, but they never permitted them to go anywhere near Krupp's. On a visit which he recalled, the German Consul in Newcastle told them they must not go near Krupp's. That was a rebuff to the employers on the North-East Coast, and the late Sir Benjamin Browne expressed himself in most forcible language against such treatment. He was convinced that if the lecturer would pay a visit to some foundries on the North-East Coast he would find some of the foundries just as well equipped as some of those he had shown upon the screen. As far as castings in marine work were concerned, he did not think any firm could turn out better work than was turned out on the North-East Coast.

THE LECTURER, in replying, said Belgium used to send castings into this country, not because she was subsidised, but because she made them cheaper. He knew that they passed things in Germany for India which would not be passed in this country. Pipes which were condemned in this country were passed in Germany. He did not think there were any moulders in the world finer than our own, but they had to face facts. With regard to Krupp's, he had had the same experience as other speakers; he had often tried to get into their place, but had never succeeded.

LABORATORY FURNACES WITH TUNGSTEN OR MOLYBDENUM RESISTORS.—A recent Paper by Mr. W. E. Ruder describes various types of furnaces developed by the research laboratory of the General Electric Company in America to meet the general needs of laboratory work. Since the discovery, by this laboratory, of methods for producing tungsten and molybdenum in ductile form, their use as resistance elements in the research laboratory of the company has grown to such an extent that they are now almost indispensable. These furnaces are used for alloy research, annealing, heat-treating, and practically all of the thermal processes requiring temperatures above 900 deg. C.

Electric-Furnace Castings on the Witwatersrand.

In the course of a discussion which followed the reading of Papers by Mr. George H. Stanley and Prof. Buchanan, at the South African Institute of Electrical Engineers, MR. J. M. DIXON gave the following particulars about locally-made shoes and dies used on the Robinson Deep. Of the total number of shoes supplied 53.1 per cent. broke at the shank. A very large percentage had holes of varying sizes and depths in the face and extending up the body, while differences of from 10 to 40 lbs. in weight of shoes of similar dimensions were observed. Five shoes broke while being picked up by the stamp, giving no life at all, and 20 per cent. of those which broke did so in the first twenty-four hours of use. These results confirm some experiments made some twelve years back at the Simmer and Jack, with imported cast-steel shoes, the conclusion then come to being that a cast shoe would not stand up to the work. A consignment of imported cast shoes are now being used on that mine, and, so far, of 55 installed 10.9 per cent. have broken at the shank, although they have not been running long. Of imported forged shoes used on the same plant during the past twelve months 3.5 per cent. have broken. The local dies supplied have been quite a success; a number have broken, but the average life is slightly better than that of the imported. The following is a comparison of life and breakages of local and imported shoes and dies of equal weights:—

	Local.	Imported.
Shoes—		
No. used	100	600
Average life (days)	23	46
No. broken	101	21
Percentage broken	53.1	3.5
Life of broken (days)	11	8
Life of unbroken (days)	37	46
Dies—		
No. used	150	600
Average life	67	64

The grouping of the results in periods will show that no progress has been made in improving the shoes: in fact the earliest consignment were better than the last received.

	No. used.	Av. life days.	Broken. No.	Broken. %
Jan.—March, 1917	45	30	15	33
April—July, 1917	30	23	14	46
August—Nov., 1917	70	22	42	60
Dec., 1917—March, 1918	45	18	30	66

The committee appointed to investigate the manufacture of these articles stated in their report that "by forging a very satisfactory product should be made," but the necessary reheating furnace and steam hammer were not included in the plant laid down. During 1913, with a view to placing a contract for forged shoes and dies, trial lots were obtained from four leading makers, and the results are given below. The average weight of stamps was about 1,550 lbs. and the duty 15 to 16 tons. The shoes were 15 by 9 in. and the weight 287 lbs:—

Maker.	No. used.	Av. life days.	No. broken.	%
A	65	68	18	20.0
B	75	64	16	21.3
C	80	66	4	5.0
D	75	67	14	18.7

Another speaker, MR. E. M. WESTON, stated that the life of the shanks could be improved by reinforcing them with steel or wrought-iron rods—that is, by casting around them.

MR. A. B. INGLIS supplied the following particulars about the locally-made electric smelted shoes and dies. The period under review covered from January, 1917, to February, 1918.

	Shoes.	Dies.
Total number used	305	205
Average weight	287.5 lbs.	132.75 lbs.
Average running time	56 days	81 days

An American Foundry.

In an article contributed to the "Iron Age," Mr. Harry C. Spillman describes the new foundry of the Lakey Foundry & Machine Company, at Muskegon, Mich. Not a single item stands out above the street level is about 20 ft. higher than the water level, with the ground gradually sloping to the lake, with railway sidings near the water edge. This makes the basement of the foundry at the

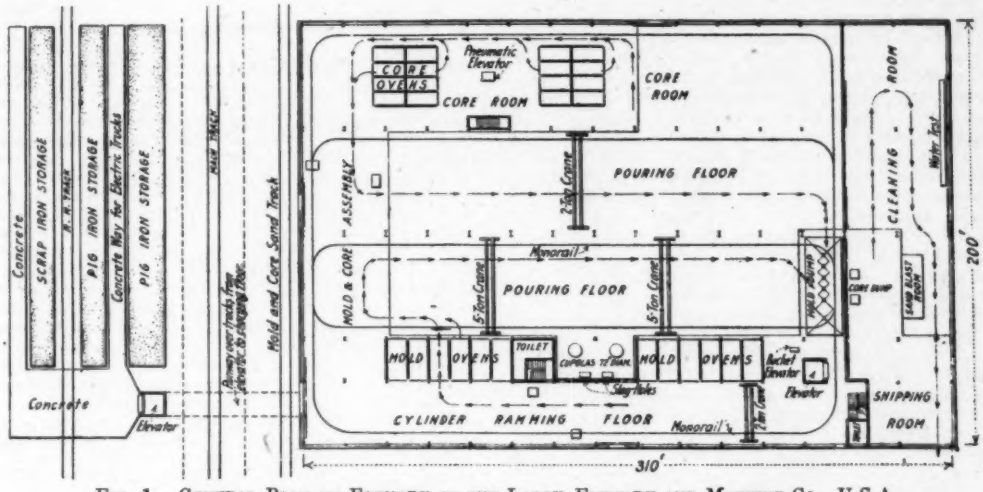


FIG. 1.—GENERAL PLAN OF FOUNDRY OF THE LAKEY FOUNDRY AND MACHINE CO., U.S.A.

the rest as of special importance—says the author—but taking the foundry as a unit they clearly prove that good foresight and efficient methods are money savers in producing castings. The entire outlay is designed to handle material with the least possible labour and at the same time to avoid automatic equipment which would have a tendency to tie up production in case of a breakdown or a delay in some department. The foundry turns out automobile castings on a basis which calls for 100 tons of castings per day in numerous sizes ranging from a few ounces to over 100 lbs. in weight.

A site was chosen having a lake frontage, and the same level as the sidings, and the first floor level with the street. It allows the sand to be unloaded in the basement and the foundry refuse handled by gravity. The foundry was built as a complete unit in itself without allowing for future extensions. It is planned to duplicate the plant as output increases; this divides the foundry into isolated units each complete in itself.

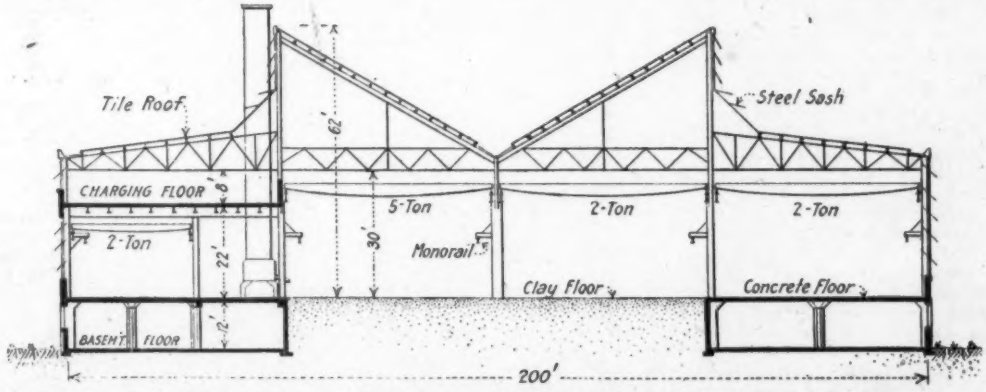


FIG. 2.—CROSS-SECTION OF LAKEY FOUNDRY, SHOWING BASEMENT SPACE ALONG EACH SIDE.

To avoid long hauls from one shop to another, the building is 310 ft. by 200 ft., having four bays the full length, instead of the customary narrow foundry with additions at different points. The basement extends under the two outside bays (as shown in cross section in Fig. 2) and across

the ends, which gives a basement under the ramming floor and core room. This gives a smooth floor and one far more sanitary than usual. The second floor extends along the entire outside bay and across the end. This arrangement gives a very large charging floor and allows the sand to be fed to the moulders by gravity.

The entire building is of reinforced concrete and structural steel. The ventilation of the building was given careful study, and a flood of daylight in every part of the building, with efficient heating by forced air, makes excellent working conditions for a foundry. All available floor space can be reached by foundry cranes and a flexible monorail system, which assists the cranes in moving material, takes care of the distribution of flasks and transfers material from one bay to another.

The handling of the core sand has proved very efficient. The sand is unloaded by a locomotive crane directly from the wagons into the bins in the basement. A covered screw conveyor flush with the floor is located every few feet in the sand bins. By removing small covers the sand drops into the conveyors and is delivered by vertical bucket conveyors to the main belt conveyor, which delivers the sand to a power screen. The screened sand is delivered direct to the sand mixers by a screw conveyor having slide valves over each mixer. The sand ready for the core makers, who work on the floor above, is delivered to them by a pneumatic elevator. The moulding sand is also stored in bins in the basement. After the metal is poured the crane picks up the mould and dumps the entire contents on a large grating. The mould sand falls through the grating into a large concrete bin (25 by 50 ft.) in the basement. Through hand operated valves under the bin the sand drops to a belt conveyor and is carried to the power screen. The screened material is taken to the second floor by a vertical bucket conveyor and placed in storage bins. It is fed as needed into mixers, where it is dumped in carts and passes through individual chutes to the first floor directly to the moulders.

The castings and cores left on the gratings pass direct to the core dump, the core refuse drops into a bin and is carried to the lake dump which is a short distance away. This makes an inexpensive way of handling the refuse. The sand-blast rooms are near the core dump and the material is laid on a shelf in the sand blast rooms through vertical sliding doors. From the sand blast it is taken to the water test, snagging room and shipping rooms.

The sand-blast sand is very inexpensive in Muskegon and no effort is made to reclaim it. The sand after being used passes in a hopper in the basement and is conveyed with the used core sand to the water dump. The dust from the sand-blast rooms is conveyed by galvanised piping to the dust arresters. The sand is stored in bins on the second floor and drops by gravity into the sand dryers below the bins. From the dryers it passes into a smaller bin over the sand-blast room and the operator fills his sand-blast machine as needed.

The fireboxes of the mould and core ovens are in the basement, which avoids the usual loss of space on the first floor, and gives easy access to all parts of the furnace. The arrangement allows the entire first floor section of the ovens to be utilised for the baking of the moulds and cores, as all the auxiliary equipment is placed in the basement. Doors are at each end of the ovens which allow the material to pass through.

The material in the yard is handled by a locomotive crane and the coke and iron are taken to the second floor by an elevator and overhead bridge. The large size of the second floor allows several days' storage during bad weather and confines all the operations indoors during severe weather conditions. The floor around the charging doors of the cupolas is made of 12-in. channels resting on I-beams, which give a smooth and durable floor.

Metal Substitutes in Germany.

As announced in these columns at the time, an exhibition of "substitutes in war times" was held in Berlin at the latter end of 1916. Admission was by special tickets only, and every recipient of such a ticket had to give a written undertaking that he would not divulge anything seen in the exhibition. The enforcement of this secrecy is evidently now being relaxed, as the German papers begin to publish more freely articles on the subject of substitutes. It is claimed that the problem has been solved with great success. The papers are, of course, not allowed to publish full information at present; bare indications can therefore only be given by them.

The electro-technical industry suffered most by the shortage of copper; and, like the engineering and shipbuilding industries, it had to content itself with zinc alloys containing 4 to 5 per cent. of copper or 2 to 3 per cent. of aluminium. In railway and tramway carriage fittings cast-iron and zinc replaced brass and copper work. Zinc was also used instead of copper and nickel for buttons, shoulder-badges, and other trappings on military uniforms. The optical industry before the war worked almost entirely on brass and aluminium. In place of aluminium it now uses an alloy of magnesium and aluminium, called elektron light metal, which is lighter and firmer than aluminium. The watchmaking and toy industry was likewise badly hit by the metal shortage. After copper, tin was one of the more important metals for which substitutes had to be found. It was used principally in alloys for bearings, tinplates and for soldering. If no substitute had been discovered for the bearings with 70 to 80 per cent. of tin, the whole of the munitions industry might have been in danger of stoppage. The situation was saved by zinc and by lead alloys. For making tinplates likewise a substitute had to be found, especially as tins for canning goods of all kinds play an important part in time of war. Other metals, but more especially prepared lac, have been adopted as substitutes. It should be added that wherever possible soldering has been avoided, and metals have been joined by rivets, notches or welding.

The metal shortage, however, has been a good lesson to Germany, for many substitutes have been discovered which are likely to be retained after the war. In the first place, malleable castings have had to be used to a greater extent than before, especially where brass was used merely for convenience. Iron and steel bars and tubes have come in for use in lieu of brass and copper in many situations; but it is zinc that has become the principal substitute for brass; and since zinc by itself is not suitable for working up, excellent zinc alloys have been turned out, only slightly inferior to brass. The problem of protecting the surface, of course, assumes a different aspect when iron or zinc is used instead of brass. It has become necessary to plate the surface of the parts with brass or nickel, but nickel is also becoming scarce. Mostly, however, the zinc parts are given a dark tinge and then covered with a serviceable lacquer.

New Gas and Air Blast Crucible Furnace.

At Messrs. Goodwins, St. George's Tool Works, Leek, our representative recently saw in operation a new type of crucible furnace fired by gas which has been placed upon the market by The Richmond Gas Stove & Meter Company, Limited, and of which we append illustrations. The body of the furnace is very stoutly constructed, and, as will be seen, is fitted with fireclay lids with wrought-iron handles, and provided with indicators and discs on the gas and air ports. A pre-heating chamber is placed between the pot hole and the flue, and beneath this chamber is disposed a coil through which the air for combustion is caused to pass, so that it attains a very high temperature before mixing with the gas. The air is delivered at approximately 15 in. w.g., though the pressure may be increased to as high as 36 in. w.g., according to the nature of the metal being melted. Gas is taken at the usual mains pressure.

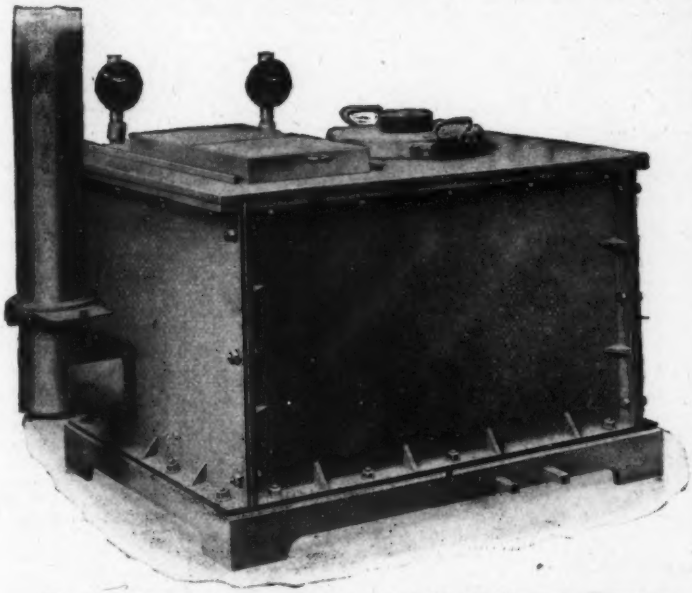


FIG. 1.—GENERAL VIEW OF GAS AND AIR BLAST CRUCIBLE FURNACE.

The furnace referred to is used for melting electric bronze (8,733), the capacity of the crucible being 100 lbs. The average number of melts from ingots and scrap is 10 per day, though, as a matter of fact, 13 melts have actually been made within the working day, with a gas consumption of 3 to 3¼ cub. ft. per lb. of metal brought down. A special crucible is employed, the life of which is from 35 to 40 melts. Under present conditions the temperature of the pre-heating chamber is approximately 900 deg. C., and in the furnace itself temperatures up to 1,450 deg. C. are readily obtainable.

FIG. 2.—VIEW IN MESSRS. GOODWINS' FOUNDRY, WHERE THE NEW CRUCIBLE FURNACE IS INSTALLED.

We append figures of a test taken over a full week, which are of particular interest, because they were obtained under the everyday working conditions of the foundry, and may therefore be regarded as thoroughly representative.

100 *lbs. Crucible Furnace.* — Composition of charge, electric bronze composed of ingots and scrap. Nature of work, sand castings. Gas consumption, average over the week per 100 lbs. melt, 300 cub. ft., having a calorific value of 550 B.T.U. gross. Number of heats, 11 per shift of 8 hours, being an average of 1 melt in 42 mins. Life of crucible, 34 melts per pot.

In one day consisting of 12 working hours, 1,011 lbs. of electric bronze were melted and cast, also one pot of aluminium. A still better result would have been obtained but for the loss of heat during meal hour, as in this time the furnace cooled down considerably. When working with aluminium a melt and pour was obtained every ten minutes. In this operation the pre-heating chamber was not utilised, owing to the quickness of the melts.

The length of life of the furnace lining will naturally vary over a wide range, dependent mainly upon the pouring temperatures and also upon the care taken of the lining by way of timely patching. In the case in point, the lining of the furnace, which it may be noted was the first built to this design, only required renewal after 10 months continuous service.

Society of Chemical Industry.

The annual meeting of the Society of Chemical Industry was held on July 17 in the Chemical Department of the Bristol University, the members being accorded an official welcome by the Lord Mayor of Bristol (Alderman W. J. Sheppard) and the Vice-Chancellor of the University (Sir Isambard Owen). The President of the society (Prof. Henry Louis, of Armstrong College, Newcastle-on-Tyne) was in the chair.

In their annual report the Council stated that the number of members on the register was now 4,794, as compared with 4,429 last year. Since the last annual meeting 571 members had been elected, and the losses had been 206. The following members of the Society had died on active service :—Messrs. Dennis H. Barraclough, Roland B. Gibbins, Walter H. Giles, Percy S Nelson, and Ralph W. Skipp.

The result of the ballot for officers and Council for the next year was as follows :—

President.—Prof. Henry Louis.

Vice-Presidents.—Dr. E. F. Armstrong, Prof. W. R. Hodgkinson, Messrs. R. L. Mond and Walter F. Reid.

Members of Council.—Sir Robert Hadfield, Bart., F.R.S., Dr. F. Mollwo Perkin, Mr. J. A. Butterfield, and Mr. C. S. Garland.

Hon. Treasurer.—Mr. D. Lloyd Howard.

Announcement was made of the award of the Society's Gold Medal to Sir James Dewar, Fullerian Professor of Chemistry at the Royal Institution since 1877 and President of the Society of Chemical Industry exactly thirty years ago.

White zirconium oxide, practically pure, is now being manufactured in this country by the Zirconium Syndicate, Limited. The production of zirconia on a substantial scale and at a commercial figure has, it is believed, never been accomplished before outside Germany.

Salts for Heating, Quenching and Tempering Steel.

We have received from Messrs. John Wright & Company, Essex Works, Aston, Birmingham, a brochure dealing with the use of salts in connection with heating, quenching and tempering of carbon steel and high-speed steel.

In atmospheric furnaces it is difficult to heat articles uniformly, whether working with a closed muffle or with an open furnace, in which the burning gases come into contact with the work. Some parts heat more quickly than others, and sometimes it is difficult to prevent sharp corners or thin parts from overheating before the remainder has become hot enough. Final uniformity may be secured by long soaking, but in many cases this is injurious to the steel under treatment. In the heat-treatment, the hardening and tempering of steel, if the processes are to be carried out with precision, and on lines which ensure the maximum efficiency and the minimum loss, it is necessary to use various liquids composed of fused salts or mixtures of salts. The temperature of a liquid may be regulated accurately, and cannot vary in a few moments, as the atmosphere of a furnace does. Any article immersed for a sufficient length of time will become heated throughout to the same temperature as the liquid, and the sharpest corner cannot be overheated so long as the liquid itself is kept at the desired temperature. The advantages of heating in a liquid are obvious, but the process has made little progress, because molten lead, the medium usually employed, is unsuitable for such a purpose, and some of the difficulties with lead are such as can never be obviated. Various kinds of "melts"—as they are called—have been evolved for various processes, and some of these are briefly described in Messrs Wright's brochure. They include :—(1) Barium chloride, used for heating high-speed steel. It fuses at about 1,760 deg. Fah. (2) "Pyromelt," used for heating carbon-steel articles or for re-heating carburised work, preparatory to quenching in water. It is not advisable to quench in oil from "pyromelt," which fuses at about 1,256 deg Fah. It is so light that the trouble, inherent to lead, of articles floating on the surface does not arise. (3) "Feusalt" fuses at about 410 deg. Fah., and is used for quenching high-speed steel, for tempering tools of either carbon or high-speed steel which require a temperature higher than about 482 deg. Fah., and for heat-treatments up to 1,202 deg. Fah. The tools are raised to the necessary high temperature, after which they are quenched-out in the "feusalt," which is very much hotter than boiling water, but not at a red heat. As soon as the tools reach the same temperature as the "feusalt" they are taken out and allowed to cool in the air. (4) "Tempermelt" is used as a substitute for "feusalt" for tempering springs, etc., which require temperatures of 842 deg. Fah. or over. It is also used for heat-treatments up to a temperature of 1,292 deg. Fah. (5) Patent "quenchoid" fuses at about 275 deg. Fah., and is used for quenching carbon steel which has been heated in an ordinary open or oven furnace. It is sufficiently swift in its action to render thin articles glass-hard, but when they have reached the temperature of the "quenchoid" they are still so hot as to undergo a slight tempering action, by which the hardening strains are released. For this reason articles may be hardened in it without risk of breakage and with a minimum of warping or distortion. "Quenchoid" is not recommended for the hardening of thick or heavy tools. It is also used for tempering tools of either carbon or high-speed steel which require a temperature higher than about 320 deg. Fah. In addition, it is used for heat-treatments up to 1,292 deg. Fah.

The rest of the brochure deals with furnaces made by the firm for use with these various salts.

British Foundrymen's Association.

ANNUAL CONFERENCE DISCUSSIONS.

Fluidity of Cast Iron.

DR. W. H. HATFIELD (Sheffield) complimented the author on the way he had presented the equilibrium diagram, adding that he entirely confirmed what Mr. Riddell had said concerning its importance. From the metallurgical standpoint it was impossible to understand the properties of cast iron until the diagram had been properly studied. Prior to writing his book on cast iron he (Dr. Hatfield) spent three years in following through the evolution of the diagram, and he regarded those years as the most profitable period he ever spent. He was, however, unable entirely to follow Mr. Riddell in his deductions. The diagram was constructed on cooling curves of alloys from nothing to 5 per cent. of carbon. Mr. Riddell had been deducing his conclusions from the properties of low carbon alloys—*i.e.*, steels containing 0.2, 0.5, up to 0.9 per cent. of carbon. The author had deduced therefrom an explanation of facts observed in connection with cast-iron. He (Dr. Hatfield) had long wished to do that himself, but found it was really impossible. The term equilibrium must first be understood. It meant that if they maintained an alloy for a sufficiently long period at a certain temperature they realised certain phases or conditions, and Mr. Riddell might take certain facts as experimentally established. The D point on the diagram was the eutectic, and if they had a 4.3 per cent. of carbon in a carbon alloy freezing would take place at about 1,130 deg.; but if they had ordinary cast iron they had anything from 1 per cent. to 3 per cent. of silicon, the presence of which generally modified the freezing-point of the iron. Its first result was to reduce the solubility of carbon, and the net result was that if they took a cooling curve of a highly siliceous iron containing, say, 3 per cent. of silicon it would freeze at a very much higher temperature. If an iron of that composition, with, say, 3.2 per cent. of carbon, was gradually raised in temperature, they would find the carbon absorb in conformity with the diagram. The time required would vary considerably. When iron was charged into the cupola and gradually heated up, sufficient time was given for equilibrium to be attained; if they took either the actual freezing-point of the alloy, or the melting-point, they would find that the points were within a degree or two of each other. Therefore, he could not agree that under the conditions of the cupola it was possible to heat up a piece of cast iron to a temperature so high as had been indicated without fusion taking place. It was impossible to escape that fusion. For example, if they took a piece of wrought iron and packed it in a box with charcoal, as was done in the case-hardening process, heating it up to a thousand degrees, 1.6 per cent. of carbon was introduced, when they reached a certain temperature—*i.e.*, the converse of the melting-point—the alloy would melt in the boxes. He would like Mr. Riddell to reconsider his theory in the light of the suggestions now offered, and he thought he would find that equilibrium would be attained much more readily than was stated in the paper. No doubt, if it had been that equilibrium was difficult to attain, the results described might follow, but in actual foundry operations they could melt ordinary foundry iron containing 1¼ per cent. of phosphorus in a much shorter time than Mr. Riddell had said, and the smallest articles could be cast therefrom, the degree of super-heat being sufficient. Mr. Riddell had emphasised the importance of the sufficiency of super-heat, which was fundamental; but it was necessary also to emphasise the importance of that heat, not only because of the ease with which the teaming was carried through, but because of the influence which the casting temperature had upon the cast iron. For example, if they took an iron containing only a relatively small proportion of silicon, regarded as belonging to the harder type of foundry iron, say, containing 1.25, if that iron were cast very hot they would find quite a considerable quantity more combined carbon than if they cast it cold. In the same way the effect of sulphur was much more exaggerated when the casting temperature was high, and he suggested that the practical men in the foundry interested in mechanical properties of the material should investigate it from that standpoint. They would find that the effect was great.

MR. RIDDELL said that while he appreciated Dr. Hatfield's remarks, he would like to hear the practical foundryman on the subject. In the Glasgow district, whenever they talked about the cupola the difficulty was to bring a meeting to an end. The equilibrium diagram was built up in the simplest possible way, and he did not believe that the changes took place so rapidly as Dr. Hatfield would have them believe. He had personally conducted some experiments, and he was melting iron in a crucible at different rates in order to ascertain the temperature to which he could raise it before it became fluid. He quite agreed that silicon promoted fluidity in cast iron; but he had met with no other theory which would explain all those peculiar phenomena with which they were familiar in the foundry. However, he was prepared to further consider the matter.

MR. R. CARRICK (Shipley) said he would like to draw attention to certain statements made by Dr. Hatfield—*i.e.*, that the higher the temperature of cast iron the greater the combined carbon, and consequently the harder the iron. Although he was not a metallurgist, he (the speaker) had made thousands of practical tests of cast iron, and he had never yet found that the higher the temperature of cast iron the more likely they were to get harder iron. He thought Dr. Hatfield might offer at some future time a further explanation of that. He (the speaker) had tested hardness with the Brinell and other tests, and his own experience certainly did not confirm that statement. He thought most foundrymen agreed that the hotter they cast the iron the softer it would be. Leaving aside the question of chemical content, he thought mechanical tests would confirm that theory, though on that matter he would like to hear Mr. Cook's views. Many practical men were in the position of knowing that certain things took place without being able to explain them. Personally, he would like to hear a further discussion on that subject in the future.

DR. HATFIELD, replying to further remarks, said that his statement with regard to the effect of temperature was based upon actual experiment and observation, and many of those experiments could be very easily carried through. He had found that iron cast hot was distinctly harder than iron cast cold. He would give actual experimental data in support of that statement. His experiments in

the first place consisted of a gradual increase in the silicon content, and he really did the work primarily to see how the results compared with those published by Professor Turner in 1881. He increased the silicon content by stages of 0.25, 0.50, 0.75, right up to 3 per cent. of silicon, and then he determined the result by fracturing the casting and testing both the combined carbon and the mechanical properties. One thing he discovered was that the gradual addition to the silicon content did not result in a gradual precipitation of the graphitic carbon. In his experiments he found that the combined carbon remained at a high maximum, well over 3 per cent., until a certain silicon content was reached, and then he found a rapid drop. In that series the casting was done at a fairly cold temperature. In the next series, with the silicon content identical, he cast much hotter, and he found that the combined carbon persisted until the higher silicon content was reached, and that was confirmed over and over again in works practice. If they had a very heavy casting with a sufficiently high silicon, the effect of casting temperature would be different, because they would always have a maximum softness. If they had such large castings, for example, as were made by the President—say, castings up to 60 tons, 90 tons and 100 tons—they could imagine that with a mass of cast iron like that and with silicon under 1 per cent., the cooling would be so slow that the carbides would be completely broken up.

Answering a question by Mr. Mayer, Dr. Hatfield explained that exactly the same sort of furnace was used and the conditions were the same in each case. He employed a special melting apparatus, and the metal was never in contact with the fuel. The accounts of the experiments would be found in the "Iron and Steel Institute Journal" for 1906.

Mr. F. J. Cook (Birmingham) said that Dr. Hatfield's concluding remark really contained the crux of the whole matter. It was not only a question of hot or cold casting temperature, but also a question of the range of cooling. When dealing with hard iron, which very quickly cooled, say, for super-heated steam-engine cylinders, the metal was very susceptible to hardness, and therefore very susceptible to the influence of the rate of cooling, and if they were not very careful they got *very* hard iron before they were aware of it. If the range of cooling was increased the possibility of softness was increased. He did not wish to throw doubt upon what Dr. Hatfield had said, but personally he had cast thousands of cylinders, and there was no doubt that in casting cylinders with metal of the kind he had described at a high temperature they would be more easily machinable than if cast with metal of the same analysis cast cold. That was due simply to the different range of cooling. He believed that was the whole crux of the matter.

LONDON BRANCH.

Cupola Blowing and Efficient Combustion.

The following is the discussion on this Paper (see page 417), read before the London Branch by Captain Alexander Hayes, Mr. T. W. Aitken in the chair :—

The President called attention to the fact that the paper put a 1 : 10 ratio of coke per ton of metal as a good one. Whilst admitting that, it was the general experience that a more fluid metal was required with light castings than with heavy castings, and for that purpose the ratio should be about 1 : 8. A high-silicon metal required to be at a higher temperature than a low-silicon metal in order to get more fluidity, and the ratio of coke would necessarily vary with varying classes of metal.

The Author agreed. He had in mind the same class of metal when used on light and heavy castings respectively; but founders would of course require different heats according to the class of work.

Mr. Stone asked which was the best place to put the gauge in the case of three cupolas working together. Would it be best to have a separate gauge for each or one gauge coming out of the pipe between the three, to determine the pressure and velocity of delivery to each cupola?

The Author said that while for some purposes it might be sufficient to have the gauge in the general main at any point between the blower and the cupola, since the condition of the tuyeres would have an effect, it was better to instal indicators which would read for each cupola. He had no preference for running the air-pipes from the blower overhead or underground. From the purely practical standpoint, undoubtedly the overhead mains were best, because an increased temperature of the air was obtained and obstructions in the pipes were more easily obviated. With underground systems there was a tendency towards the accumulation of dirt, and that might have a serious effect on the recording apparatus.

Mr. W. H. Aston said it seemed to him that what they wanted to do as practical men was to take a certain cupola or cupolas and test them in order to find out what they were doing. Only by comparing notes in that way could they help each other. Then they could apply some of the things that had been pointed out in the paper. For example, if somebody had a 3 ft. 6 in. furnace, let that be tested and discussed, and then compared with another furnace. Unless they proceeded in that way they would not get much assistance from such a paper as the present one. Until they did something on those lines they would not, as practical founders, get very much more forward.

Mr. Slater said that to himself, as a practical founder, the Paper had gone a good deal farther than many papers that had been published or read before the Branch. The whole crux of the cupola question was summed up in the author's statements. As to slag in the tuyere holes, the suggestion in the Paper was quite right. The height of the charge and the difference in charge affected the pressure-gauge to a considerable extent. They might run a cupola one day at the ame pressure as on another, but with different results. Atmospheric conditions also altered the condition of the iron when it came down. On a wet day there did not seem to be the same fluidity in the metal that there was on a nice bright day. He had experimented with the pressure-gauge to determine the right position, and found very little difference whether it was 1 ft. from the blower, half-way between the blower and the cupola or on the top of the belt.

Mr. Lambert endorsed the previous speaker's remarks as to the value of the Paper. He regarded the author's statement that the pressure-gauge rise records the resistance to the entry of the air and not the amount entering as a most important one, and for that part of the Paper alone they were indebted to the author. What did Capt. Hayes regard as the best volume recorder? What was

the best laboratory instrument that could be adapted to foundry practice?

Mr. H. G. Barrett said that in some foundries it was still possible to find square and circular conduits. Which did the author prefer, and why?

The Author replied that he did not attach very great value to the shape of the conduit, because they were not out initially for fine economies in horse-power absorbed by the system. There was generally plenty of power available somewhere on the system. The difference in the frictional effect between the two forms was not great. Personally, he was of the opinion that the form of the conduit was not a vital factor. It was different when dealing with very high velocities and more viscous fluids than air. Mr. Aston had put his finger directly on the weak spot of the Paper when he pointed out that it did not give complete directions for running a cupola blowing system. The Paper had been written as an introduction to the subject, with the hope of supplementing it by experiments and facts. Owing to the war, however, the experimental work had been absolutely stopped. He heartily endorsed what Mr. Aston had said, that a founder should take a cupola and experiment with it, and such experiments need not be a costly matter. But the prime essential was the installation of an air-quantity recorder. It was a matter which would have to be taken up very shortly if any progress was to be made in connection with cupolas, because things were at a point where mere mechanical improvements had reached their limit. Now it was a question of chemical improvement in the process of combustion, and improvement in prevention of heat radiation. The volume recorder was the next thing to consider. He himself had recently experimented with Pitot tubes and sensitive diaphragm indicators of the aneroid type, but the latter were very sensitive to damage and were easily put out of order by dropping or jarring. He did not think that a sensitive diaphragm indicator would be much use for practical purposes in the foundry.

Mr. R. Reid said his foreman had devised a simple way of approximately determining the volume of air passing. He counted the revolutions of a certain wheel on the driving system, and when it was going at 35 he knew that he was not getting enough air and that the metal was not being melted properly. At 45 the proper amount of air was being delivered. If the speed was greater than this, then the coke burned out before the iron was properly melted. It was not an absolute but it was a relative gauge of the amount of air that was coming in.

Mr. T. Clayton (the foreman who had employed this method) said he chalked the pulley and counted the revolutions as it went round.

The Author agreed that for the particular plant this probably acted as an approximate indicator, though not a positive gauge, of the volume passing. It was certainly a useful indicator, but it would not do in all cases, as the power behind the fan might enable it to turn against a quite appreciable resistance.

Mr. Slater, on answer to a question as to the results obtained with placing his gauge in different positions, said he got the lowest result when the gauge was on top of the belt.

The Author, in answer to a question as to the horse-power generally required to melt a ton of iron, said that horse-power had no reference whatever to the amount of air coming in. The horse-power was merely a measure of the force required to deliver a certain quantity of air through a given size and length of main, or against a given total resistance. One horse-power could deliver a huge quantity of air under certain conditions, or the same quantity might require 5 h.p. under slightly varying conditions, and it would be hopeless to hazard any opinion as to the weight of iron melted. Also, the amount of coke might vary 30 per cent. and the air as much, according to the rate of melting. As to the position of the pressure gauge, as mentioned by Mr. Slater, it would be found as a general rule that the nearer they got to the cupola, or the farther away from the blower, the lower would be the pressure-gauge readings, because the system as a whole absorbed a certain amount of the initial pressure.

Queries.

Fuel/Iron Ratio in Cupola Melting.

Query.—Will you inform me, by an example, how to calculate the fuel/iron ratio in melting, taking the appended charge-sheet as an example.

Reply.—The term "fuel/iron ratio" is rather loosely applied, and may or may not include the bed coke. Also, it may refer to the iron actually charged, or to the iron actually recovered as molten, i.e., charge less melting loss. For purposes of cupola investigation we consider the bed-coke proper should be excluded from the calculation; but for works practice, where actual fuel expended for iron produced is required, it is necessary to count all coke charged (less any amount recovered on raking out or dropping the bottom after the day's blow), against the iron actually melted and tapped. Hence the calculation should be:—

	Cwts.	Cwts.
Total coke charged into cupola	19.5	
Less coke recovered at end of blow (say)	0.8	
Coke actually consumed		18.7
Iron charged:—		
Brand "A"	84	
" "B"	32	
" "C"	19	
" "D"	16	
Scrap, gates, &c	110	
	211	
Less loss in melting, say about 5% ...	11	
Available molten iron		200

$$\text{Fuel/iron ratio} = \frac{18.7}{200} = \frac{1}{10.69}$$

In the above example the amount of coke recovered has been assumed, as it varies considerably, and was not shown in the charge-sheet. The loss of iron in melting also is assumed, but shall not be much in excess of 5 per cent in good practice. Many founders, in calculating the fuel/iron ratio, neglect to allow for recovered coke and iron lost; but this should be done if correct figures are desired. In every-day practice, however, it is simpler to use the recovered coke from the previous day's work, without entering it on the charge-sheet, either as consumed or recovered. Thus the one day's savings are off set by the consumption of the previous day's savings, and neither needs to be taken into the calculations.—A. H.

Selwyn's Metric Conversion Tables.—Edited by W. Erskine Dommett, A.F.Ae.S., M.I.Mar.E., etc. (London: James Selwyn & Company, Limited, 20, Essex Street, Strand, W.C. Price 2s. 6d. net.)

This is a little handbook of tables for men engaged in various branches of engineering and science. They number 31 in all, and cover a wide range of requirements where metric and English equivalents are needed. The metric system is so much in vogue at present that all engineers need to deal in both systems, and a ready means of conversion is extremely useful.

Deaths.

MR. J. F. ROEBUCK, of the Hepworth Ironworks Company, died recently.

THE death has occurred at Kirkcaldy of Mr. A. Hunter, the permanent engineer of the Forth Bridge.

MR. C. TYZACK, of Messrs. J. Tyzack & Sons, saw manufacturers, etc., Meersbrook Works, Sheffield, died recently.

MR. T. A. TELPHER, the North of England and Scotch representative of John Shaw & Sons, Wolverhampton, Limited, died recently at the age of 41 years.

THE death took place recently, at South Shields, of Mr. C. W. Taylor, ironfounder, who took a close interest in the affairs of the town. He was 61 years of age.

LIEUT. B. C. RANSOME, second son of the late Mr. R. C. Ransome, founder of Ransomes, Sims & Jefferies, Limited, has been killed in action. He was a director of the company.

MR. G. W. WILLCOCKS, M.Inst.C.E., formerly chief engineering inspector, Local Government Board, died on July 7 at his residence, 9, Rodway Road, Roehampton, at the age of 70 years.

THE death took place on July 7, at 2, Park Terrace, Queen's Park, Glasgow, of Mr. J. L. Carty, of J. L. Carty & Company, engineers, Oswald Street, Glasgow, at the age of 54 years.

The death occurred on the 11th inst., at his residence, "Woodley Field," Hexham, of Mr. Edward Sisterson, iron and steel merchant, Newcastle-on-Tyne. Mr. Sisterson established the business carried on in his name about 45 years ago, and was well known in steel trade circles.

AFTER an illness extending over some weeks, the death has occurred at Durham of Mr. George Oldham, who had attained the age of 62 years. He was the eldest son of the late Mr. S. Oldham, who carried on until his death the Framwellgate Iron Foundry, and the reins of management were thereafter taken over by the deceased, who was in charge until the works were dismantled some few years ago.

THE death of Mr. J. A. Duncan, of Logie Aston, Bridge of Allan, and Glasgow, took place last month. Mr. Duncan belonged to an old Glasgow family, and for many years was intimately associated with the iron trade of the West of Scotland. He was chairman of the Coltness Iron Company, Limited, and was well known on the Glasgow Royal Exchange.

WE regret to announce the death, which occurred suddenly, on June 27, of Mr. Arthur Thomas Kent, J.P., of Harborne Park, near Birmingham, the eldest son of the late Mr. Arthur Keen, of "Sandyford," Edgbaston. The deceased gentleman, who was 57 years of age, was educated for the legal profession and called to the Bar, but did not practise for long, preferring a commercial career. After leaving the Bar he became associated with the firm of Guest, Keen, & Nettlefolds, Limited, of which his father was chairman. Mr. A. T. Keen performed many of the duties that devolved upon his father during the last few years of the latter's life, and ultimately succeeded him as chairman of the company.

MR. I. BEARDMORE, J.P., of Lymington Lodge, Bothwell, has died, after a brief illness. The deceased gentleman was associated with the management of the Parkhead Forge, Glasgow, for about twenty years, fully fifty years ago he became a partner with his brother, the late Mr. William Beardmore—father of the present head of the firm—and although it is about 30 years since he severed his connection with the steel trade, he is remembered by many as one of the early pioneers of the Siemens-Martin process in Scotland. He was instrumental in converting the Parkhead Forge from an iron to a steel works, about 1880. When Mr. William Rigby, the original partner with the late Mr. William Beardmore in the ownership of the Parkhead Forge, retired from the business in the late sixties, Mr. I. Beardmore joined his brother in the management of the concern. The death of Mr. William Beardmore occurred in 1877, and Mr. I. Beardmore thereafter continued the management as senior partner until 1886, when the present chairman of the company, Sir William Beardmore, assumed the control of the business, which has since been so vastly extended. Mr. I. Beardmore was 82 years of age.

Personal.

SIR CHARLES PARSONS has been elected president of the Polytechnic School of Engineering (London).

MR. G. E. CHADWYCK-HEALEY has been appointed Director of Materials and Priority at the Admiralty.

THE gross value of the estate of the late Mr. Alfred Vaughan, brassfounder, of Wolverhampton, is £6,550.

THE gross value of the estate of the late Mr. Isaac Whitehouse, brassfounder, of Birmingham, is £5,348.

ESTATE of the value of £21,445 has been left by the late Mr. T. B. Pegler, iron merchant, of Putney Hill, S.W.

THE late Mr. W. S. Bradley, of Somerset Grange, Edgbaston, Birmingham, metal manufacturer, left £57,883.

MR. W. H. ALLEN, chairman of W. H. Allen, Sons & Company, Limited, has given £500 to the Bedford County Hospital.

THE late Mr. J. R. Overend, ironmaster, of Rockside, Histon Hill, Oaken, Wolverhampton, left estate valued at £16,820.

THE late Mr. J. A. McKie, of Messrs. McKie & Baxter, engineers and shipbuilders, Govan, left estate valued at £35,161.

MAJOR E. A. MARPLES, of William Marples & Sons, Limited, Hibernia Tool Works, Sheffield, has been invalided home from India.

MR. J. ROSS and Mr. R. Robertson have retired from the directorate of the Lanarkshire Steel Company, Limited, of Motherwell.

MR. C. PAYNE, managing director of Harland & Wolff, Limited, Belfast, has been appointed Director of Shipbuilding for the Admiralty national yards.

THE BRITISH GOVERNMENT has approved the appointment by the Persian Government of Mr. J. A. Hill to be Consul at Sheffield. Mr. Hill is head of the firm of J. and P. Hill, Ordnance Works, Sheffield.

MR. G. WOLSTENHOLME, of Thomas Firth & Sons, Limited, and Mr. M. R. Mainprice, director and secretary of Brown Bayley's Steel Works, Limited, have been elected directors of the Firth-Brearley Steel Syndicate, Limited

MR. FRANK BIGGIN, who has been associated with the Brightside Foundry & Engineering Company, Limited, Wicker Iron Works, Sheffield, for 36 years, has been appointed a director of the company. Mr. Biggin has grown up with the firm, joining it in 1882, when quite a small boy. After some years at the Newhall Works, he was sent to manage the Carbrook New Foundry. As the business developed he took charge of the heating department, and for the last 20 years or so he devoted his energies to that branch. The company has established a reputation as heating and ventilating engineers, and with the erection of many special types of factories for the Government, has had to design special systems of heating and ventilating. The work has been chiefly on shell factories, shell-filling factories, aerodromes, and aircraft works of all kinds, and in various parts of the country, but this has not excluded work for private concerns, so that many of the new works which have sprung up round Sheffield, Birmingham, and London, and in other parts of the country, have been equipped with the Brightside heating installation.

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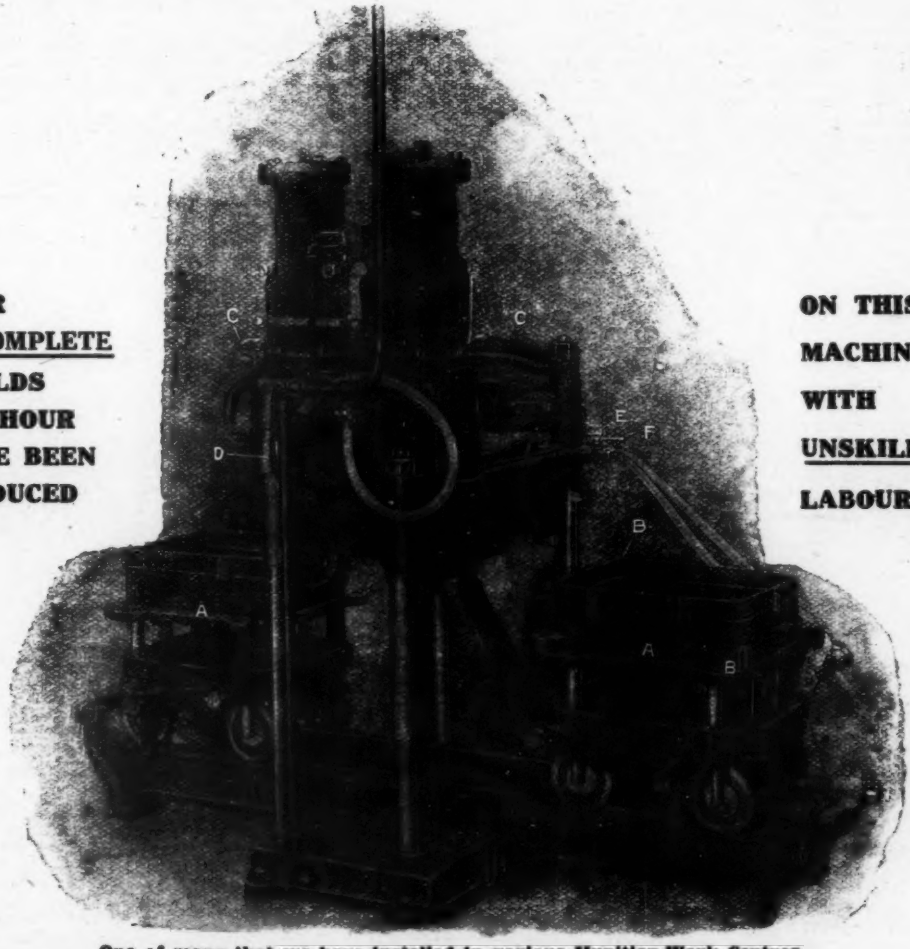

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Trade Talk.

THOMPSON BROS. (Bilston), Limited, are building a new shop at their Bradley (Staffs.) works.

THE address of the Controller of Timber Supplies is now 80, Newman Street, Oxford Street, W.1.

MESSRS. A. PICARD & COMPANY, steel merchants, have removed to 4, New Burlington Street, London, W.1.

THE capital of G. D. Peters & Company, Limited, is being increased by the issue of 100,000 shares of £1 each.

SAML. DENISON & SON, LIMITED, Hunslet Foundry, Leeds, have opened offices in London at 28, Victoria Street, Westminster, S.W.1.

BRETT'S STAMPING COMPANY, LIMITED, of Coventry, are building a new shop, for the heat treatment of steels, at their Harnall Lane Works.

THE NEW ERA TOOLS AND STAMPINGS, LIMITED, is being wound up voluntarily, with Mr. W. H. King, 13, Basinghall Street, London, E.C., as liquidator.

IT is suggested that the Sheffield Exchange meeting should be held on Wednesday instead of Friday. Mr. T. W. Ward has been re-elected president.

THE business of Messrs. Phillips & Son, Birmingham, has been amalgamated with that of Peyton, Hoyland & Barber, Limited, Bordesley Works, Birmingham.

THE VAUXHALL AND WEST HYDRAULIC ENGINEERING COMPANY, LIMITED, are being wound up voluntarily, with Mr. F. Belcher, 39, Coleman Street, E.C.2, as liquidator.

THE Millom furnaces of the Millom & Askam Hematite Iron Company, Limited, during the year have again produced more iron than in any previous year of their history.

ELECTRO-METALS, LIMITED, of London, has received an order from the Italian Ansaldo firm for the installation of six electric furnaces of 4,000 h.p. each for smelting pig-iron.

MESSRS. J. BURKE & J. CULEY, engineers' tool and hardware merchants, 8, Malt Street, and 250, Chester Road, Manchester, trading under the style of Burke & Culey, have dissolved partnership.

THE directors of W. & T. Avery, Limited, propose increasing their capital to £1,000,000 by the creation of 400,000 new shares of £1 each. This matter was dealt with at the company's annual meeting.

THE shareholders of the British Pneumatic Tool Company, Limited, have decided to wind up the company. Mr. W. H. Badams, 5, Budge Row, London, E.C. 4, has been appointed liquidator.

MR. EDGAR J. WINDSOR RICHARDS, consulting iron and steel works engineer, has removed his offices from 90, Mitchell Street, to more commodious premises at Castle Chambers, 65, Renfield Street, Glasgow.

MESSRS. T. PRESCOTT and F. BLACKWELL, engineers, iron and brass founders, Victoria Works, Victoria Road, Leeds, trading under the style of the Cotwell Foundry Company, have dissolved partnership.

MESSRS. THOMAS SMITH & SONS, steam and electric crane works, Rodley, near Leeds, have converted their business into a private limited company, under the style of Thomas Smith & Sons (Rodley), Limited.

To avoid misunderstanding, Thos. Oxley, Limited, of the Shiloh Works, Sheffield, wish us to state that they have no connection with any other firm, either in Sheffield or elsewhere, bearing the name of Oxley.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN, which had its origin in one of the Clyde yards, has removed its headquarters from Glasgow to 8, Victoria Street, Westminster, London, S.W.

MOSS & GAMBLE, BROTHERS, LIMITED, have been registered with the capital of £100,000 in £1 shares to take over the existing business of steel manufacturers at the Franklin Works, Sheffield, and at Wadsley Bridge.

METAL AND MACHINERY SYNDICATE, LIMITED, 56, and 57, Aldermanbury, London, E.C.2, have been wound up under the Trading with the Enemy Amendment Act, 1916. The Controller is Mr. P. H. Green, 60, Watling Street, Queen Victoria Street, London, E.C.4.

MR. JUSTICE SARGANT, on Tuesday, sanctioned a scheme of arrangement of the Rubel Bronze and Metal Company, Limited, and confirmed a reduction of capital from £100,000 to £60,000. The nominal amount of the shares would be reduced from £1 to 12s.

THE partnership heretofore subsisting between Messrs. H. Burnley, F. Lambert, and E. Smethurst, ironfounders, 12, Lower Ernest Street, Bradford, under the style of Lambert, Burnley & Company, has been dissolved.

MESSRS. E. FILDES, J. H. Crawshaw, C. E. Crawshaw, P. E. L. Crawshaw, and T. Crawshaw, engineers, etc., Statham Street, Pendleton, Salford, trading under the style of Crawshaw, Fildes, & Company, have dissolved partnership, so far as concerns Mr. E. Fildes.

BILLINGS & SPENCER COMPANY (GREAT BRITAIN), LIMITED, 36-37, Upper Thames Street, London, E.C.4, have taken over the selling rights for Great Britain and Continental Europe for machinists' tools manufactured by the Billings & Spencer Company, Hartford, Conn., U.S.A.

MESSRS. J. BLAKEBOROUGH & SONS are making important extensions to their Woodhouse Works, Brighouse, Yorks., which include a large machine and fitting shop, a brass foundry and brass finishing department, whilst on the opposite side of the street a roomy workmen's canteen is nearly completed.

THE Board of Trade have prepared for the introduction of a rationing scheme for imported soft wood timber, commencing as from July 22. A schedule of maximum prices for imported timber will be issued, but will not apply to existing stocks, which will still be subject to the previous regulations as to price.

ASHWORTH, SON & COMPANY, LIMITED, of the Midland Ironworks, Dewsbury, are extending their erecting shop by an additional bay 50 ft. by 43 ft., and building a general stores. They have also acquired additional land adjoining the works to provide for future extensions, the recent acquisition bringing the total available land up to approximately 5 acres.

THE PATENT SHAFT AND AXLETREE COMPANY, LIMITED, have now adjusted the difficulties in regard to the site for their blast-furnace plant. With the first furnace it is now only a matter of erection, as the furnace parts, stoves, and other auxiliaries have been in the possession of the company for a considerable time. The company, however, have in contemplation the erection of a second furnace.

MR. OSWALD SEWELL, of Birmingham, for five years the Midland representative of William Jessop & Sons, Limited, Sheffield, but who for the past two and a half years has been engaged in the Steel section of the Ministry, has accepted the position of manager of the New York branch of Messrs. Wm. Jessop's business, and will leave England to take up the duties of the position at the end of September.

SIR WM. C. GRAY has purchased a site at Seaton Carew for the purposes of a shipbuilding yard. The Southwick U. D. Council has approved plans for additions to the Wearside shipyards of Swan, Hunter & Wigham Richardson, Limited, and the Concrete Shipbuilding Company, Limited. At the meeting it was stated that another new shipyard is to be laid down on the Southwick side of the Wear.

Replying to SIR WILLIAM BEALE, SIR A. STANLEY said that in dealing with applications for licences under the provisions of Section 20 of the Companies Consolidation Act, 1908, due provision was made for the payment of reasonable remuneration to members of the Council of Management of such Industrial Research Associations, with the approval of the Department of Scientific and Industrial Research.

ALFRED HICKMAN, LIMITED, Spring Vale Furnaces, near Wolverhampton, anticipate that the new open-hearth plant, which comprises two 80-ton tilting fur-

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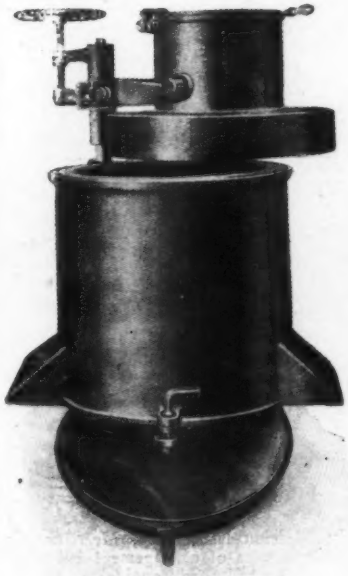
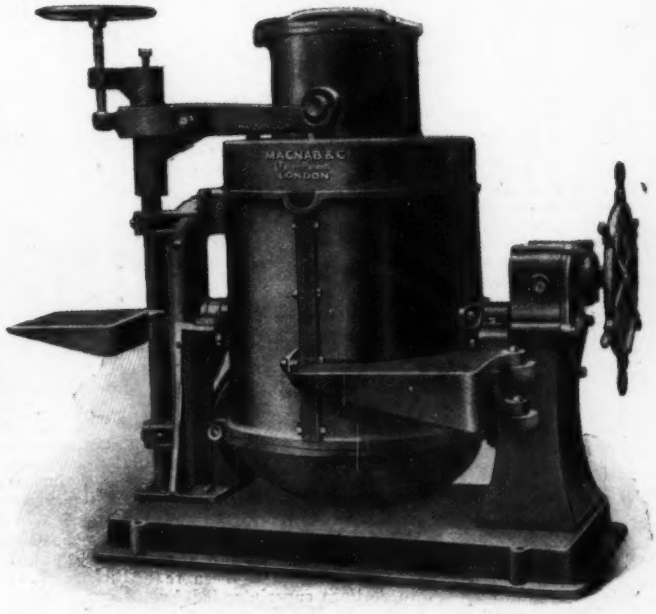


Tylor Patent Pit-Type Furnace.

OUTPUT.
200 lbs. Admiralty Gunmetal melted in 5 minutes. Temperature 2000° F.

ECONOMY.
20 lbs. of Coke used per 200 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 35 to 40 heats.



Tilting-type Furnace.

OUTPUT.
400 lbs. Admiralty Gunmetal melted in 45 minutes. Temperature 2000° F.

ECONOMY.
73 lbs of Coke used per 400 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 35 to 40 heats.

naces (by Wellman, Seaver, & Head, Limited), will be in full operation in the course of the next three months. Certain minor alterations are being made in the first furnace, in which a trial melt has already been made, and the second furnace is nearing completion. Shortage of skilled labour has delayed the work very considerably.

THE inevitable economic struggle and the accentuation of competition which must take place after the war have, amongst other reasons, induced the University of London to institute Degrees in Commerce and to develop a scheme for both practical and theoretical training in co-operation with the leading commercial interests in the Metropolis. To this end a meeting was held under the presidency of the Lord Mayor at the Mansion House on July 18, when the Right Hon. A. J. Balfour, M.P., was the principal speaker. The outlines of the scheme were submitted, and a general committee was formed for the furtherance of the aims in view.

ARRANGEMENTS have been made, after consultation with the Ministry of Munitions and the Department of Scientific and Industrial Research, and in conjunction with the British Chemical Ware Manufacturers' Association and the British Laboratory Ware Association, for testing at the National Physical Laboratory of scientific glass-ware, etc., on a more comprehensive scale than hitherto. The tests will include:—(a) Volumetric tests on graduated vessels of all kinds; (b) tests on the resistance to chemical action, and as to the general suitability of vessels for use in chemical processes; (c) tests on filter paper, porcelain ware, etc., as used in physical and chemical laboratories. The conditions of test, and scale of charges, are given in the Test Pamphlet of the Metrology (Glass Testing) Department, copies of which may be obtained on application to the Director.

THE Industrial Reconstruction Council has been registered as a company limited by guarantee (not formed for profit). The objects are to assist in the promotion of efforts (whether by Government or otherwise) to bring together representatives of capital and labour for the advancement of trade, etc., to act as the representative and mouthpiece of subsidiary councils, to assist in the formation of boards of conciliation and arbitration, to give the Legislature and public bodies or other facilities for conferring with and ascertaining the views of persons engaged in any particular trade or industry, etc. The first directors are:—Sir Wm. Stokes, W. Ripper (Vice-Chancellor of University, Sheffield), E. J. P. Benn, F. H. Elliott, Sir Chas. Allom, W. Birch, E. Kimber Bull, Emil Davies, W. Garnett, J. L. Garvin, D. T. Holmes, M.P., T. B. Johnston, A. W. Kirkaldy (Master of Commerce at Birmingham University), Lieut.-Colonel C. L. Malone, Sir Herbert Nield, K.C., M.P., Major S. Pascall, Sir Alexander Roger, H. O. Thomas, and B. Tillett, M.P. The work of the Industrial Reconstruction Council is expanding so rapidly that it has been found necessary to secure more adequate office accommodation, and the address of the organisation will in future be, 2 and 4, Tudor Street, E.C.4. The work has been reorganised and divided into sections superintended by sub-committees. Mr. Ernest J. P. Benn remains chairman and administrative chief, Sir Alexander Roger is in charge of the membership section. Dr. William Garnett and Mr. Emil Davies control meetings, and Sir Herbert Nield, K.C., M.P., is Parliamentary representative. The Council is also extending the work of propaganda through other organisations, and is now prepared to send speakers to any societies to lecture or initiate discussions upon the various aspects of the Whitley Report. Applications should be made to the secretary, who would also be glad to supply literature for distribution.

THE directors of Brown, Bayleys Steel Works, Limited, have been considering very carefully the financial position of the company in special reference to the large extensions carried out during the war. These extensions have enabled the company to take a leading part in the production of alloy and other special steels for aeroplane work, etc. After consultation with their solicitors and auditors the directors are proposing to wind up the present company and sell to a new company to be formed with the same name. This will enable the memorandum and articles of association, which are thirty years old, to be revised. The new company will be registered with a capital of £800,000, divided into £300,000 ordinary shares and £500,000 preference shares. The shareholders in the old company are to receive four £5 ordinary shares for each old £10 share, and two £5 ordinary shares for each old £5 share. If the shareholders agree to the scheme the directors will offer £300,000 preference shares to the shareholders and their friends privately for cash. It is proposed that the preference shares shall carry a cumulative dividend of 5 per cent. free of tax, and have a preference both in regard to capital and dividend as against the ordinary shares.

THE London Iron and Steel Exchange, which was recently registered, will not be opened for business until the conclusion of hostilities, but, nevertheless, considerable progress is being made with the scheme. The membership of the company is limited to 40, the following being a list of the firms who have so far joined:—G. Bailey, Toms & Company, Laurence Pountney Hill, E.C.; C. L. Faulkner, Laurence Pountney Hill, E.C.; B. Hingley & Son, Limited, Netherton; F. Hodge, Limited, Upper Holloway, N.; Moss, Isaacs, Limited, 122, Cannon Street, E.C.; W. Jacks & Company, 5, East India Avenue, E.C.; Kenrick, Arch & Company, West Bromwich; A. G. Kidston & Company, 148½, Fenchurch Street, E.C.; F. Lloyd & Co., 85, Gracechurch Street, E.C.; H. W. Meredith & Son, Lambeth, S.E.; Miles, Druce & Company, Upper Thames Street, E.C.; McArthur & Co., King's Cross, N.W.; Rowson, Drew & Clydesdale, Limited, Upper Thames Street, E.C.; Redpath, Brown & Co., Limited, 22, Laurence Pountney Hill, E.C.; H. J. Skelton & Company, Finsbury Square, E.C.; Smith & Wellstood Limited, Stirling; Watson Slack, 102, Bishopsgate, E.C.; Standard Range & Foundry Company, Watford; G. Warren & Company, Cullum House, E.C.; Yates & Company, Billiter Street, E.C.; Brown & Tawse, Dundee; Brooker, Dore & Company, 5, Fenchurch Street, E.C.; H. B. Barnard & Son, 148, Fenchurch Street, E.C.; A. Campbell (E. C. Koops), Spencer House, South Place, E.C.; Croggon & Co., Upper Thames Street, E.C.; Dutton, Massey & Co., Laurence Pountney Hill, E.C.; J. & J. Drysdale, 78, Queen Victoria Street, E.C.; Enterprise Steel Company, 113, Queen Victoria Street, E.C.; H. Faulkner, Limited, 363, Old Kent Road, S.E.; A. Cameron & Co., 206, Mansion House Chambers, E.C.; H. W. Peabody & Company, 16, Eastcheap, E.C.; Grovesend Steel & Tinplate Company, Limited, Gorseinon, Glam.; A. W. Crosthwaite, Limited, Thornaby-on-Tees; W. J. Firth, 29, Great St. Helen's, E.C.

IN the Chancery Division last month, Mr. Justice Astbury sanctioned a scheme of arrangement between Richard Hornsby & Sons, Limited, engineers, Grantham, and the holders of the company's various debenture stocks and preference stock and shares, for the purpose of carrying out an amalgamation with Ruston, Proctor & Company, Limited, engineers, Lincoln. Under the scheme the holders in Hornsbys are to receive in exchange holdings in Rustons, the name of which is to be changed to Ruston & Hornsby, Limited. The assets of Hornsbys are to be transferred to the purchasing company, which is to take over the whole of the debts and liabilities, including the debenture stock of the vendor company. Every shareholder in Hornsby will be entitled to claim an allotment in respect of each £1 of preference stock one "B" preference share of the purchasing company fully paid, and in respect of every two ordinary shares of £10 each in the vendor company 17 ordinary shares in Rustons of £1. This, said Mr. Russell, K.C., was

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worked out on the market values of the shares, and that Hornsby was getting a fair bargain was shown by the fact that since the scheme was put forward the market price of the shares had risen in value. The purchasing company was increasing its capital from £950,000 to £1,600,000.

In their report the directors of the General Electric Company, Limited, state that the company has recently entered into an agreement for the purchase of the whole of the works of Fraser & Chalmers, Limited, at Erith. The actual purchase price will only be ascertained after the valuation of the assets has been completed. It is proposed that the capital of the company should be increased to £3,000,000, by the creation of a further 100,000 preference shares of £10 each and 600,000 ordinary shares of £1 each. The directors suggest creating a fund for the superannuation, pensioning off and benefit of the employés of the company, or their families or dependants. For this purpose they contemplate allotting to trustees shares to the value of £25,000—the unissued balance of the ordinary share capital. The reserve account now stands at £500,000, and the directors propose to capitalise £300,000 of this reserve by converting it into 300,000 ordinary shares of £1 each, and distributing such shares amongst the existing ordinary shareholders in the proportion of five £1 shares for every £10 share now held. The directors propose shortly to raise £1,000,000 further capital by an issue of preference and ordinary shares, for which the sanction of the Treasury has been obtained. In view of this issue the directors have thought it desirable to raise the dividend both in respect of the existing preference shares and of the new preference shares from 6 per cent. to 6½ per cent.

Legal.

John Hall and Sons v. Showell and Sons.

In the House of Lords, the Lord Chancellor, Viscount Haldane, Lords Dunedin and Parmoor have given judgment in an appeal by the plaintiffs in the case of John Hall & Sons, Limited, v. Edwin Showell & Sons, Limited. The plaintiffs, who carry on business at Mounting Works, Lye, near Stourbridge, sued the defendants, brassfounders and metal workers, of Birmingham, to recover damages for breach of contract for the manufacture and supply by them for the defendants of 145,000 18-pounder cartridge clips. The clips were to be made of steel to be supplied by the defendants. This steel the defendants, in fact, failed to supply, and they thereby prevented the plaintiffs carrying out the contract. The claim for damages was based on the loss of the profits which the plaintiffs calculated they would have made if the defendants had taken delivery. The claim was for £474 1s. 7d., being the excess of the contract price over what would have been the cost to the plaintiffs of making the clips. The liability of the defendants was not now in contest, the only question being as to the damages. At the trial Mr. Justice Bailhache gave judgment for the plaintiffs, but the Court of Appeal allowed the defendants' appeal for a new trial. It was against the order for a new trial that the plaintiffs appealed to the House of Lords. By a majority the order for a new trial was affirmed.

The Stanton-Holwell Amalgamation.

The directors of the Stanton Ironworks Company, Limited, near Nottingham, have, subject to the approval of the Treasury, entered into a provisional agreement with the directors of the Holwell Iron Company, Limited, of Melton Mowbray, under which the shares of the Holwell Company will be acquired by the Stanton Company.

The Stanton Company employs some 7,000 workmen in connection with their blast furnaces and foundries at Stanton collieries, near Mansfield, and ironstone fields, in Leicestershire and Northamptonshire. The Holwell Company employs some 1,200 workmen in connection with their blast furnaces and foundries at Melton Mowbray and ironstone fields in Leicestershire and Lincolnshire.

The combined companies—Stanton with its nine and Holwell with its four blast furnaces, and additions now in course of erection—will be the largest producers of pig-iron in the Midlands. Both companies have established a world-wide reputation for their cast-iron pipes and general castings, and in this direction their combined output is far in excess of any similar undertaking in this country.

Hardware Ration Scheme.

The General Advisory Committee on Hardware Imports announce that, subject to the following exceptions, the rations for the six months commencing August 1 next, have been fixed at the same rate as the current rations, i.e., 50 per cent. of 1915 imports.

Ration holders should accept the intimation and should refrain from addressing correspondence to the Department on the subject of the amount of such rations. Those who have not imported the whole of their present ration by July 31, are given time to do so until January 31, 1919. After the latter date any portion of either ration which has not already arrived in the United Kingdom will be licensed only as against any further ration that may be granted in 1919.

The limitation of price will continue as at present. Price control is held to apply to a sale by a ration holder of imported ration goods bought by him from another importer. For goods which it is necessary to bring from the United States the Department of Import Restrictions is prepared to grant permits now for ordering or shipping goods not exceeding the ration up to January 31, 1919. The Controller reserves the right to refuse permits or to prohibit or postpone importation of any article at any time, even though a ration has been declared.

Firms not now holding rations will not be granted rations from August 1, except in very special circumstances. Such cases will be considered in consultation with the General Advisory Committee.

Applications for Patents.

Ashcroft, E. A. Manufacture of magnesium and calcium metals and alloys and obtainment of by-products in process. 10,808. July 2.

Griffin, P. J. Roofs for metallurgical furnaces. 9,962. June 17.

Greenwood & Batley. Annealing furnaces. 10,379. June 24.

Hadfield, Sir R. A. Manufacture of iron silicon alloys. 10,924. July 3.

Harbord, A. W. Tempering ovens or furnaces. 10,957. July 4.

Knowles, J. A. Recovering scrap steel and dolomite discharged with slag from Siemens open-hearth, etc., furnaces, and disposing of slag. 10,469. June 25.

Lord, J. Metal-melting furnaces. 10,216. June 20.

Manuel, E. Process for case-hardening steel and tempering. 9,643. June 12.

Marsh, C. Treatment of metals and refractory materials and of tools or crucibles made thereof and in electric furnaces used therefor. 10,997. July 4.

Morfett, J. E. Furnaces for melting lead, etc. 10,763. June 29.

Morgan Crucible Company and Spiers, C. W. Crucibles for electric furnaces. 9,822. June 14.

Rennett, W. R. Steel-heating furnace. 10,026. June 18. (United States, August 16, '17.)

Rosborg, A. H. Furnaces. 9,983. June 17.

Stabilimenti Biak—Ing. A. Pouchain. Metal alloy containing manganese. 10,209. June 20. (Italy, March 9.)

Stabilimenti Biak—Ing. A. Pouchain. Metal alloy. 10,210. June 20. (Italy, March 16.)

Sumitomo Chukosho, Limited. Magnet steel. 10,531. June 26. (Japan, June 15, '17.)

Whittingham, J. Method of moulding for casting. 9,787. June 14.

AS SUPPLIED TO H.M. WAR OFFICE.

THE ORIGINAL AND BEST CORE COMPOUND.

"SPERMOLIN"

(Registered Trade Mark.)

For particulars apply to the Makers :—

THE SPERMOLIN CORE CO.,
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HALIFAX.

Telegrams :—"SPERMOLIN, HALIFAX." *Telephone :—397 Halifax.*

...TRADE... SIROCCO ...MARK...

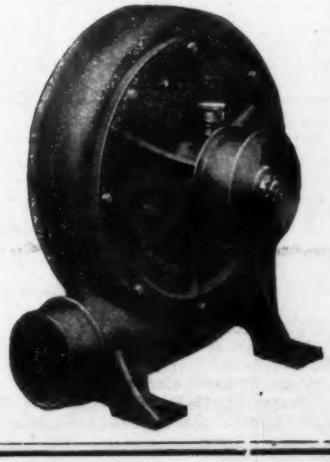
High Pressure Fans

FOR CUPOLAS.

Write for Bulletins :
Nos. 2000 F.
„ 2028 F.

Davidson & Co., Ltd.
Sirocco Engineering Works,
BELFAST.

FOR FORGE FIRES.



New Companies.

Bushey Park Machine Works, Limited. — Capital £5,000 in £1 shares.

Metallurgical Research Company, Limited.—Capital £3,000 in £1 shares.

Aero Engine Reconstruction Company, Limited. — Capital £3,000 in £1 shares.

West Suburban Tool and Engineering Works, Limited.—Capital £30,000 in £1 shares.

Taylor & Farley, Limited.—Capital £88,500 in £1 shares, to acquire the existing business.

Engine Specialists, Limited.—Capital £10,000 in 9,000 preference shares of £1 and 10,000 deferred shares of 2s. each.

Ives Engineering Company, Limited.—Capital £5,000 in £1 shares. Registered office:—97, New Bond Street, W.1.

Fleet Engineering Company, Limited. — Capital £15,000 in £1 shares. Registered offices: 64, Haymarket, W.

Draycott Engineering Company, Limited.—Capital £5,000 in £1 shares. Registered office:—97, New Bond Street, W.1.

Vitrified Grinding Wheels, Limited. — Capital £100,000 in £1 shares. Registered office: Doxey Works, Stafford.

John Jardine, Limited.—Capital £100, in £1 shares, to carry on the business of ironmasters. The first director is E. Jardine, M.P.

Newport (Mon.) Shipyard, Limited. — Capital £500,000 in £1 shares (250,000 preference). Registered office: 21, Ironmonger Lane, E.C.

Pinfold & Brown, Limited.—Capital £5,000 in £1 shares (4,400 ordinary and 600 preference), to carry on the business of tool manufacturers.

Champion Engineering Company, Limited.—Capital, £2,000 in £1 shares. Registered office: St. James' Chambers, 38, Church Street, Sheffield.

Bush Engineering Company, Limited. — Capital £2,000 in £1 shares, to take over the existing business at Bulwer Street, Shepherd's Bush, London, W.

Cosmore, Limited.—Capital £12,000 in £1 shares, to carry on the business of oscillation valve manufacturers. Registered office: 11, Clerkenwell Green, E.C.

Heginbotham-Gregson Company, Limited.—Capital £1,000, to take over the existing engineering business. Registered office: Hartley Works, Lees Street, Stalybridge.

Metallic Electrodes, Limited.—Capital £10,000 in 9,500 ordinary shares of £1 each, and 20,000 deferred shares of 6d. each. The first directors are T. Rouse and W. S. Leefe.

Lightowler & Keighley, Limited.—Capital £6,000 in £1 shares, to carry on the business of textile machinery manufacturers. Registered office: Soho Works, Thornton Road, Bradford.

George Sellar & Sons, Limited.—Capital £75,000 in £1 shares, to acquire and carry on the business of agricultural engineers and ironfounders. Registered office: Granary Street, Huntly.

Edward Matthews, Limited.—Capital £10,000 in £1 shares, to take over the business of ironfounders carried on by E. Matthews and E. Vaughan at Lion Foundry, Bradley, near Bilston, Staffordshire.

Southern Shipbuilding & Engineering Company, Limited.—Capital £5,000 in 4,500 ordinary shares of £1 each and 10,000 deferred shares of 1s. each. Registered office: 9, Mincing Lane, E.C.

Baymin, Limited.—Capital £1,000 in £1 shares, to carry on the business of iron, steel, tinplate, metal, hollowware and hardware manufacturers. Registered office: Grove Street Mills, Birmingham.

Bosper & Company, Limited.—Capital £1,500 in £1 shares, to take over the business of a toolmaker, etc., carried on by R. W. Pearson, at Birmingham. Registered office: 73, Pershore Street, Birmingham.

B. Huntsman, Limited.—Capital £75,000 in £100 shares, to take over the steel-making business carried on at Attercliffe, Sheffield. The first directors are H. F. Huntsman and Mrs. M. J. Huntsman.

Crescent Engineering Company, Limited.—Capital £1,000 in £1 shares, to adopt an agreement with J. H. Johnson. The first directors are: R. Butterworth, F. Butterworth, and F. Rawson (all permanent).

R. K. M. Tool and Engineering Company, Limited.—Capital £3,000 in £1 shares, to take over the business carried on by J. W. Reynolds, W. Mason, S. F. Burns, and F. P. Heath, at Herrick Street, Wolverhampton.

The Southern Shipbuilding and Engineering Company, Limited, has been registered with a capital of £5,000. The first directors are R. de Q. Quincey and L. W. Gill. The registered office is at 9, Mincing Lane, E.C.

F. L. HUNT & CO..

FOUNDRY
FURNISHERS
AND
FOUNDRY REQUISITES
Of every description.

56, 58, 60, CHAPEL STREET, SALFORD, MANCHESTER.

SOMETHING NEW FOR METAL MELTERS AND ENGINEERS.
Crucible Problem Solved.

THE NON-CRUCIBLE ELIPTICAL TYPE FURNACE,

For melting STEEL, PIG-IRON, Ferro-Manganese, Copper, Brass, Aluminium and all other Ferrous and Non-ferrous Metals.

Most Rapid and Economical System To-day.

500 to 2,000 lbs. capacity. (CAN BE USED AS A CONVERTOR.)

For full particulars apply:
MONOMETER MANUFACTURING CO. (1918), Ltd.,
WHITEHOUSE STREET, ASTON, BIRMINGHAM.

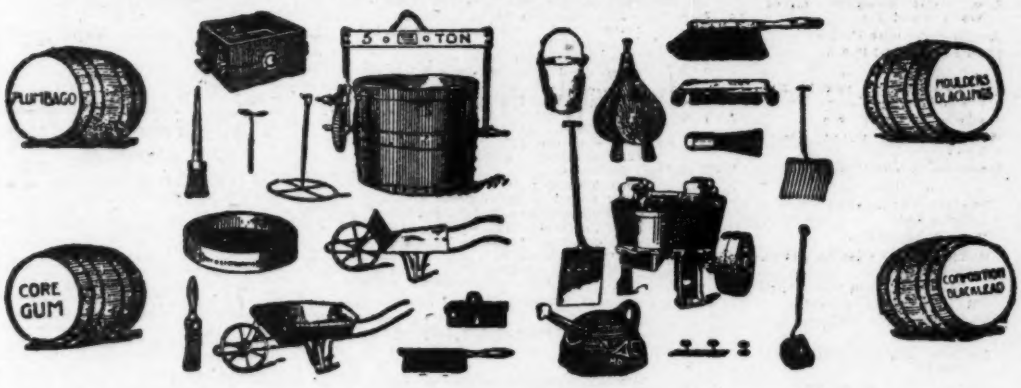
Chairman: H. J. THOMAS, Esq.
Managing Director: I. HALL, M.I.Mech.E., M.I.S.I.

Telegrams: "Durrans, Penistone." Telephone: 21, Penistone

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



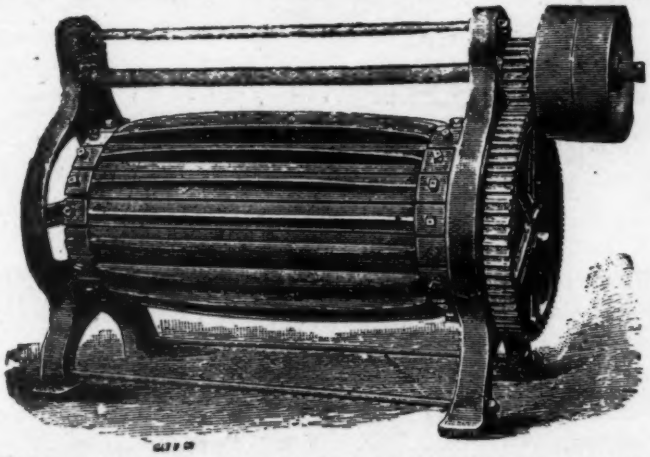
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself:—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos. 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
„ „ 0.02 „	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Scotch hematite, mixed Nos. 1 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
HEMATITE—MALLEABLE— Refined—			
Refined Cupola Cast	8	0	0
Refined Cupola Cast to guaranteed analysis..	8	5	0
Cast direct from Blast Furnaces—			
Small Pig-Iron, all grades ..	7	10	0
Medium Pig-Iron White to Grey mottled	7	5	0
Medium Pig-Iron, all other qualities	6	17	6
Large Pig-Iron, all grades ..	6	17	6
Lincolnshire, basic or foundry ..	4	17	6
Cleveland, No. 1	4	19	0
„ other grades	4	15	0
„ basic	5	0	0
Northamptonshire, forge	4	7	6
„ fdy numbers	89/0		94/0
„ basic ..	4	17	6
Derbyshire, forge	4	10	0
„ foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
„ „ foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
„ „ foundry	4	17	6
„ „ basic	4	17	6
South Staffordshire—			
Part mine forge	5	0	0
„ foundry	5	2	6
Common Staffordshire ..	4	15	0
All mine forge	5	15	0
„ foundry	6	0	0
Warm air forge	7	5	0
„ foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Basic	4	17	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works Mers. Com. 1¼%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung.	3s. 8d.
Finished bars, 18% Tung.	4s. 5d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings	8d.
Bar Ends	9d.

Both per lb. net delivered steel makers' works

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	—		
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	—		
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	—		
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	—		
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	—		
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	—		
Ferro-titanium: 23/25%, per lb. carbonless	—		
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..	—		
Ferro-phosphorus: 20/25%. Per ton	—		
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained	—		
*Ferro-manganese 80%	26	10	0
„ export ..	—		

* F.o b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s	d.	£	s.	d.
Standard, Cash ..	122	0	0	122	10	0
Three months ..	122	0	0	122	10	0
Electrolytic	137	0	0	133	0	0
Tough	135	0	0	131	0	0
Best selected ..	135	0	0	131	0	0

Tin.

Standard, Cash ..	387	0	0	388	0	0
„ Three months	387	0	0	388	0	0
English Ingots ..	387	10	0	—		
Bars	388	10	0	—		
Refined	—			—		

Spelter.

American	54	0	0	50	0	0
Specials..	—			—		
Hard	45	0	0	46	0	0
British	56	10	0	57	0	0

Lead.

Soft Foreign (net) ..	29	10	0	28	10	0
English	—			Nom.		

Antimony.

Regulus	—			85	0	0

Aluminium.

Virgin Metal 98/99% per ton	—

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots.. ..	—
CASTINGS.	Per lb
I. or II.	—
III. IV. o V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
„ Cored Bars	—
Delivery 2 Cwt. free to any town.	
10 per cent. Phosphor Copper ..	£50 above price of best selected copper.
15 per cent. Phosphor Copper ..	£70 above price B.S.
Phosphor Tin (5 per cent.) ..	£30 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM).

*Chromium (Metallic).

98/99% purity, per lb.	—

*Nickel.

In cubes, 98/99% purity Per ton	—

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks ..	—
„ rolled to spoon size ..	—

*Tungsten Metal Powder.

96/98% purity.. per lb. ..	—

*Molybdenum Metal.

96/98% purity.. per lb ..	—

*Cobalt Metal.

97% purity .. per lb. ..	—

Quicksilver.

75 lb. bottle	—

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	s.	d.
Steel scrap, heavy melting..	—		—	
Iron scrap cast (cupola metal)	—		—	

London (f.o.b.).

Heavy steel	104	6
Light „	55	0
Heavy cast	110	0

Control Prices.

Heavy Steel Melting Scrap 105	0	125	0
Steel Planings, Turnings and Borings		65	0
Steel Planings, Turnings and Borings mixed with Wrought Iron, &c.		50	0
Steel Scrap, all other Classes ..		95	0
Wrought Iron Scrap		125	0
Ditto, mixed with Steel		95	0
W.I. Planings, Turnings and Borings mixed with Steel, &c.		50	0

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations:—

	A. Joseph. £ s. d
Hy. Electrolytic Copper Scrap ..	—
Hy. Selected Scrap Brass ..	—
Hy. Tinned Copper Wire	—
Best Selected Gunmetal Scrap ..	—
Re-melted Ingot Lead	—

Stocks.

Metals.

	Tons.
Copper, Europe and afloat	—
Tin, London, Holland, U.S.A. and afloat	—

Coke.

Middlesbrough.

	s.	d.	s.	d.
Gas Coke	45	0	—	
Foundry	65	0	—	

Glasgow.

Foundry Coke	—		47	0
Furnace Coke	37	0	—	
Gas Coke	—			

London.

Welsh or Durham Foundry, d/d London Stations in truck	45	0	53	0
Ditto, d/d Birmingham Stations	44	0	48	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6		

CONTROL PRICES OF COKE.

	s	d
Durham and Northumberland blast furnace	33	0
„ foundry	38	0
Yorkshire, Lancashire, Staffordshire, Notts., Derbyshire, Lincs, & Midland Counties blast furnace	32	0
South Wales blast furnace ..	37	6
„ foundry	50	6

All per ton net. f.o.t. ovens.

Cumberland blast furnace	37	9
d/d West Coast furnaces		

SITUATIONS VACANT AND WANTED.

GENTLEMAN desires partnership in up-to-date Iron Foundry business; 25 years' practical experience. Capital, and excellent connection in the Manchester district.—Address, Box 955, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

PATTERN MAKER.—Permanent position offered to suitable man in small controlled works, preferably one with experience in pattern-plate making for moulding machines. 50-hour week. No person already on Government work will be engaged.—Apply, your nearest Employment Exchange, mentioning No. A5353.

QUALIFIED CHEMIST, with well-equipped private Laboratory, is open to receive samples of Iron, Fuels, etc., for analysis. Accuracy and promptness guaranteed.—Apply, Box 954, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

PRACTICAL Foundry Manager, with engineering and metallurgical qualifications, capable of organising and managing on modern lines foundry for high-grade Iron and Bronze Castings; commercial experience; highest references; desires appointment immediately.—Address, Box 982, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

MOULDERS wanted, used to light aluminium and brass castings, for Aero Engine work, for large Aircraft Factory in North-West London.—Apply, stating age, wages and experience, to Box E. M., c/o W. H. Smith & Son, 55, Fetter Lane, E.C.4. No one engaged on Government work or residing more than ten miles away need apply.

PRACTICAL FOUNDRY MANAGER desires appointment; very wide and varied experience (gray iron, malleable and brass), motor, textile and general light castings trade; expert moulding machines and metals; good commercial experience; sound organiser; highest references.—Address, Box 974, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

PIG IRON and FOUNDRY MACHINES.—Agencies wanted for France after the War by Commercial Engineer Agent.—Please answer to DESHERCES ALBAN, 6, rue de l'Hôpital, Angoulême, Charente, France.

FOR SALE AND WANTED.

DIE CASTINGS.—Wanted, practical, working Charge Hands, capable of taking control of Dies.—Apply, stating age, wages, and experience, to ROBERT W. COAN, 219, Goswell Road, London, E.C.1.

VERZOCCHI & DE ROMANO

MILAN (Italy).

Importers of

MINERALS. METALS. ALLOYS.

also

REFRACTORY MATERIALS and all requisites for the Engineering Trades.

Correspondence Invited.

FOR SALE AND WANTED.—*Continued*

CORE MAKING for IRON CASTINGS.—(1) Makers or suppliers of Notched Wire; (2) Makers or suppliers of effective Core Binders—Linseed Oil substitutes.—Address, Box 980, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

Offer required for

10 tons Hand Picked Selected Heavy Scrap Brass.

Ready for crucible (domestic scrap).

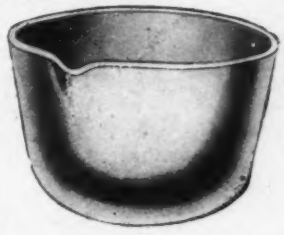
Can be seen by appointment in London.

Apply Box 988, Offices of the Foundry Trade Journal, 165, Strand, London, W.C.2.

WANTED, one second-hand 600-lb. Wright's lip-axis tilting furnace.—Send full particulars, conditions, date installed, etc., to Box 986, Offices of *The Foundry Trade Journal*, 165, Strand, London, W.C.

ROTARY TABLE SAND BLAST MACHINES second-hand, required for urgent Government work. Diameter of table 70 ins.; capacity 20 tons iron castings per hour.—Send all particulars to Box 976, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

SANKEY



Pressed Steel **Foundry Ladles**

Plain or Lipped.

Joseph Sankey & Sons, Ltd.,

Hadley Castle Works, **Wellington,** Shropshire.

Established 1890. Telegrams: Wm. Olsen, Hull.

CORE GUM. — **GLUTRIN.** — CORE OIL.

PARTING. — PLUMBAGO.

WAX CORE VENTS.

METALLIC CEMENT. — **RESIN.** — GANISTER.

Motto—'The Right Articles at the Right Price.'

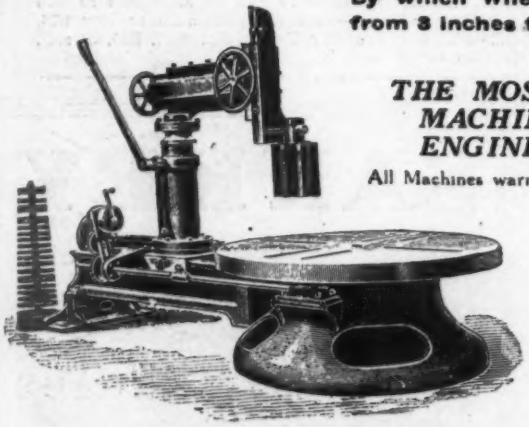
WILLIAM OLSEN, Ltd.,

Materials and Requisites for Ironwork, Brassfounders, &c.,

COGAN STREET, HULL.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

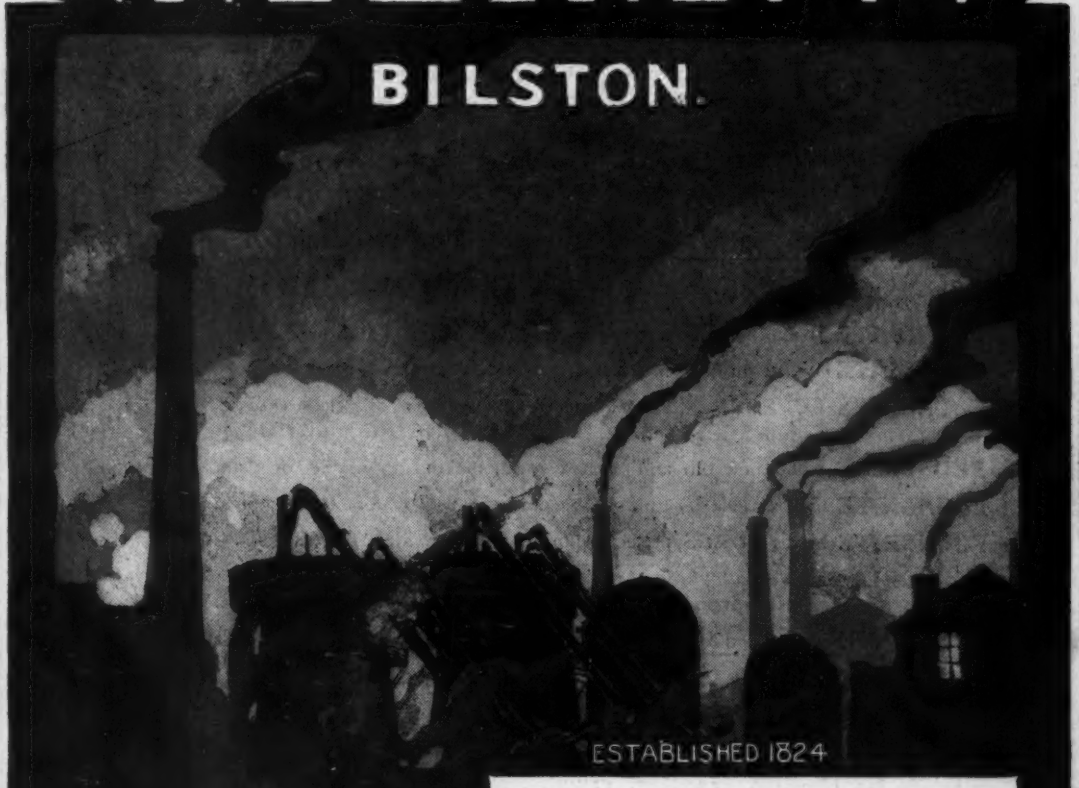
ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, *OLDHAM.*

CAPPONFIELD

BILSTON.



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Special Pig Iron

We can meet your requirements in

SPECIAL

Foundry Irons

CAPPONFIELD BRANDS.

C.A.M.	All Mine
C.C.B.	Cold Blast
ZENITH	Refined

Thomas & Isaac Bradley, Ltd.,
Capponfield Blast Furnaces,
— BILSTON. —

"FOUNDRITE."

"FOUNDRYMEN have been seeking this material for years."

Supplied only in 40 gallon Casks. No bulk broken.

FOUNDRITE is another German speciality superseded and improved.

FOUNDRITE is **the** binding material for moulding sand and cores.

FOUNDRITE SUPERSEDES and makes unnecessary all classes of **CORE GUM, LINSEED OIL and all other BINDING material.**

FOUNDRITE will renew old and burned sand, making it usable over and over again.

FOUNDRITE makes **CORES** unbreakable and the use of **core irons** unnecessary.

FOUNDRITE leaves **CORES** perfectly porous and does **not shrink.**

FOUNDRITE has been **"found right"** for all **Sand binding** in the Foundry **for all purposes.**

FOUNDRITE is supplied in **LIQUID** form ready for use. Dilute with Water.

The porosity of the core is perfect, and cores so made do not shrink.

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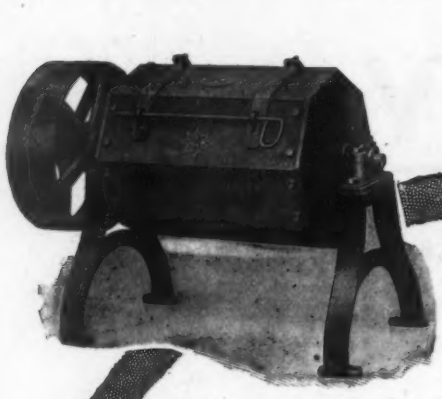

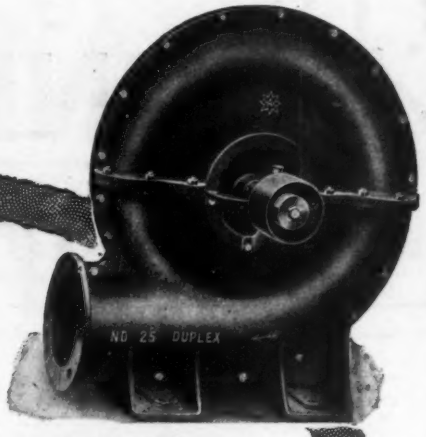

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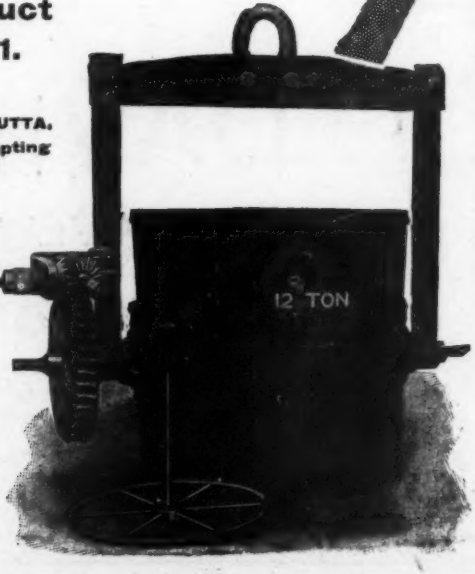

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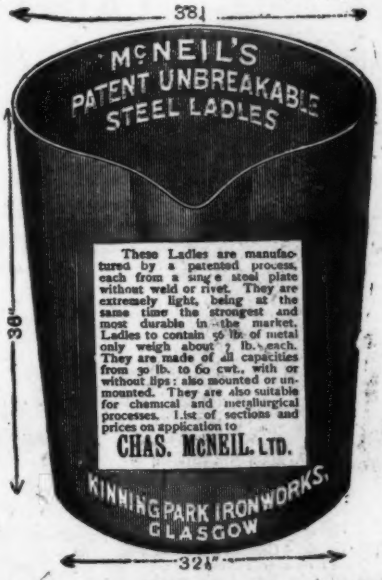
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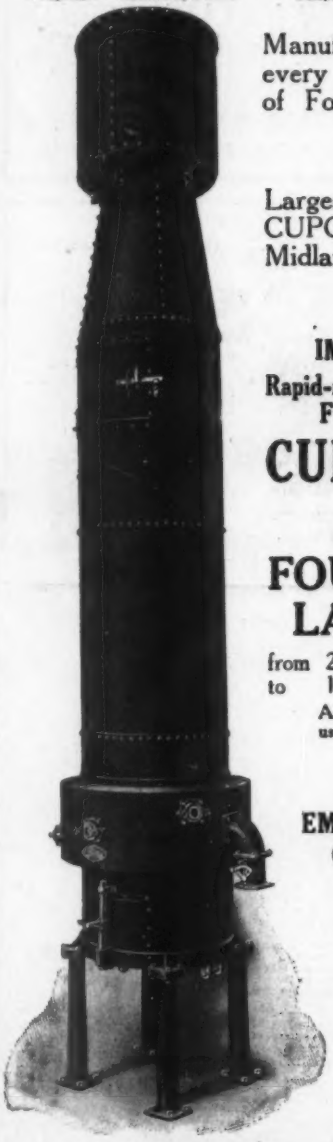

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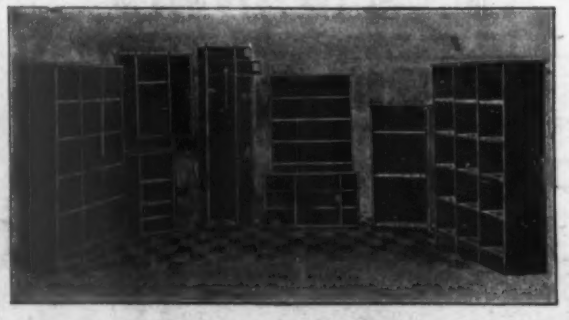

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CONTENTS OF CABINETS.

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Suitable for 50 or less Workers. Polished Wood Case. Size 9 × 6¼ × 6½ ins.

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1 Notice Card for Factory use.

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1 „ Large Body Dressings.
1 „ Small Burn „
½ „ Med. „ „
½ „ Large „ „
½ „ Sterilized Eye „
1 Bottle No. 1 Eye Drops.
1 Bottle No. 2 „ „
1 Dredger Bicarbonate of Soda.
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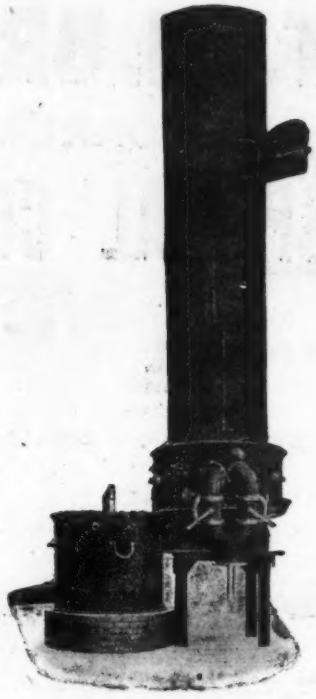

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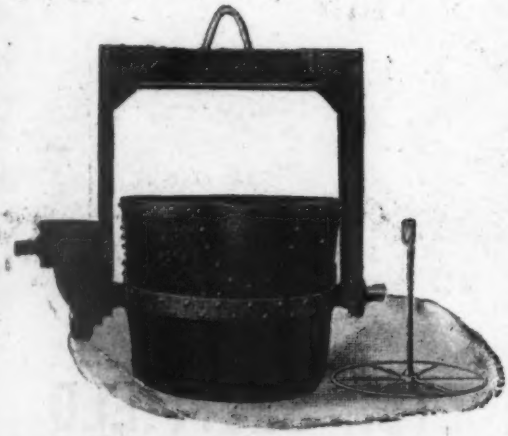

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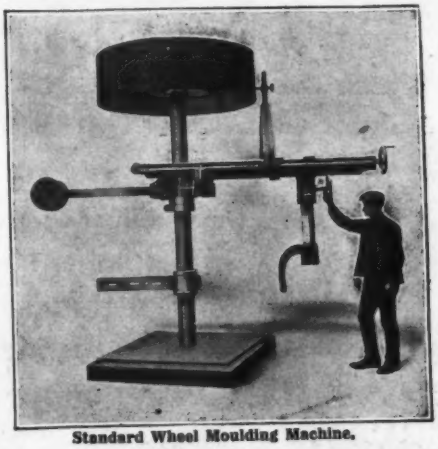

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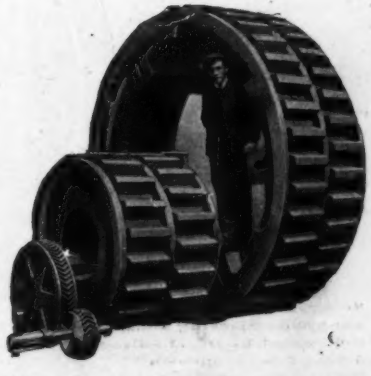

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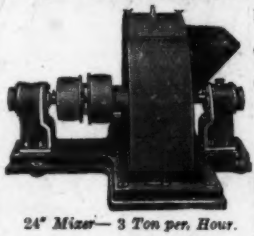

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